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RESULTS OF OPERATIONS ON PAINFUL HIPS *

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IT HAS been said that a clinical observation—carefully recorded—is always worth while, and insofar as this paper is based on the clinical records of the end-results of 142 operations on the hip-joint—100 being arthrodeses and forty-two arthroplasties—it will, I trust, prove of some interest.

The problem of the painful hip-joint in the adult, the result of trauma, of long-standing mechanical change, or old infection, is a very real one. The condition which calls for treatment may have resulted from a minor congenital defect such as a congenital subluxation; from an upset of bone growth as in pseudocoxalgia; from infection, either a low-grade, non-specific infection, pyogenic infection, or a specific infection, as in tuberculosis. It may result from trauma, as in non-union of a transcervical fracture of the femoral neck, and is perhaps most commonly seen in the degenerated or worn-out joint, which we call osteo-arthritis. In all, some degree of irreparable change has occurred.

For the present purpose, we are not concerned with the varied symptomatic remedies adopted: massage, baths, manipulation, deep X-ray therapy, or any of the varied forms of non-operative treatment. These measures, together with the use of the walking caliper or other weight-relieving splints, have their place. We will consider only those cases in which conservative treatment has failed to relieve the pain, and we were forced to explore the possibilities of relief by operation.

There are two indications for operation: (1) persistent pain; and (2) progressive deformity, disabling the patient; there are also two types of operation: (*a*) arthrodesis and (*b*) arthroplasty.

Such operations as the chipping away of osteophytic outgrowths, the so-called cheilotomy, seem to me to be of very doubtful value. Of the uses of simple osteotomy I have but little experience for these cases, for I prefer to fuse the joint at the same time.

I propose to cite a small series of cases illustrating some of the problems, and showing the after-result, insofar as an X-ray can show it, and the methods we have adopted; after which I will give a brief summary of our results.

The following illustrative cases are selected as showing types for which operation is indicated and the detail of operation used, together with reasons for the choice.

* Read before the American Surgical Association, at Toronto, Ontario, June 15, 1934.

CASE REPORTS

CASE I.—Illustrates the use of a reconstruction by the method of Dr. Royal Whitman for a painful arthritis of the hip (Fig. 1). *Result.*—Good function.

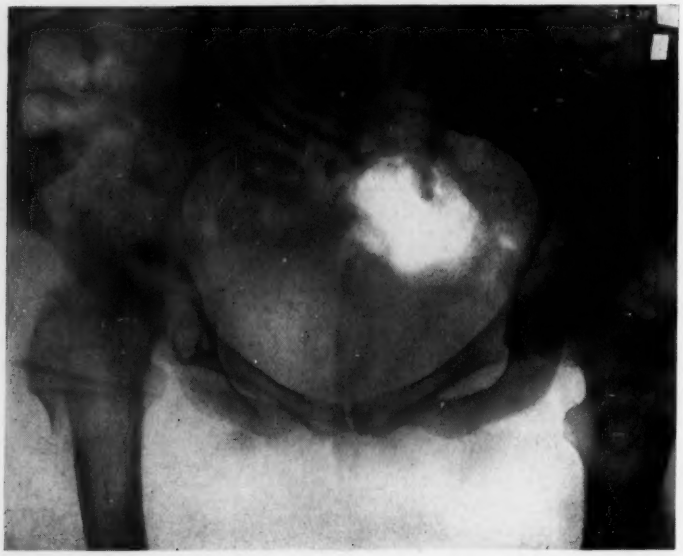

FIG. 1.—(Case I.) The result of the operation in a woman aged thirty-nine years, eight months afterwards.

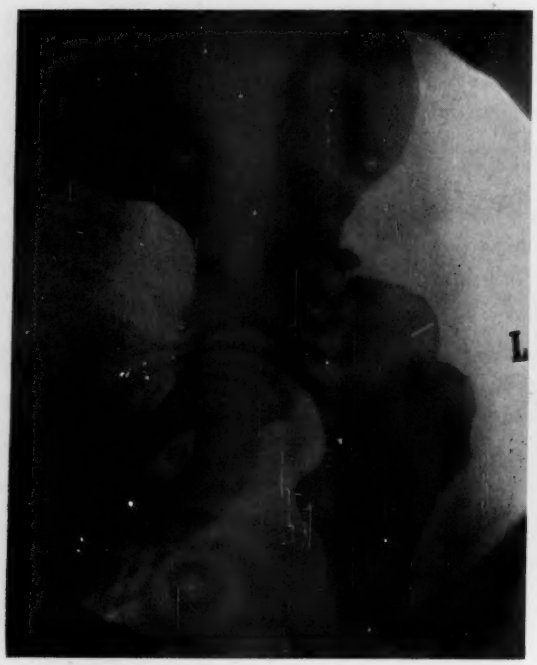

FIG. 2a.—(Case II.) The hip-joint in a woman aged twenty-eight years, the result of either a congenital subluxation or pseudocoxalgia.

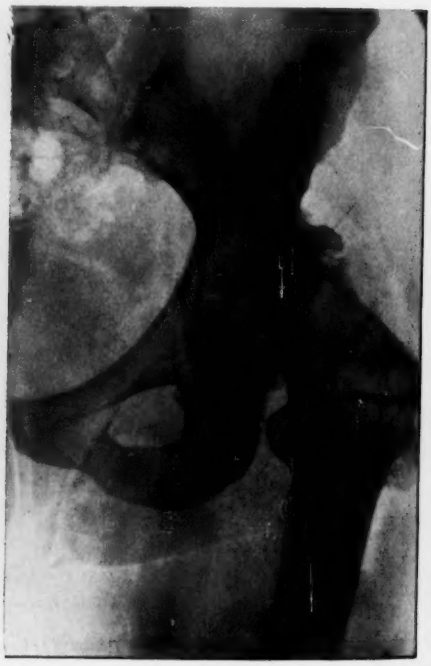

FIG. 2b.—(Case II.) The result of an arthroplasty of the hip some years later.

Remarks.—She had suffered for many years with a painful hip and a stiff knee on the same side, and this disability necessitated an attempt to get movement in the hip-joint, hence the selection of arthroplasty and not arthrodesis as the method of treatment.

CASE II.—Illustrates the use of an arthroplasty as an alternative to arthrodesis, in a non-infective arthritis in a young patient (Figs. 2a and 2b). The hip was chronically painful, completely disabling the patient. *Result.*—In this patient nearly perfect function

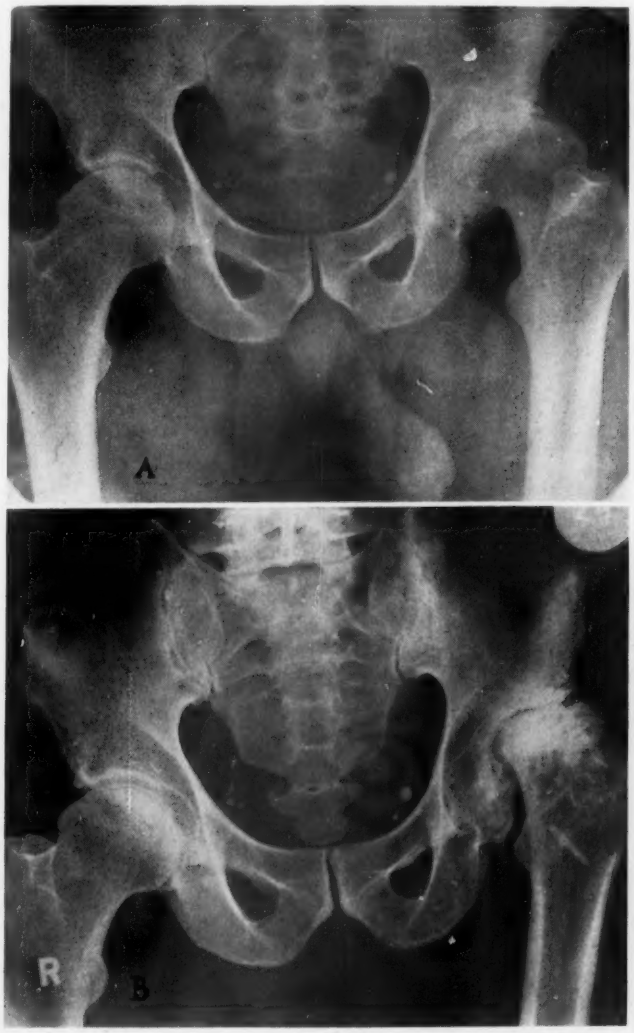

FIG. 3a.—(Case III.) The left hip of a man aged sixty-four years, crippled and with chronic pain, so-called osteo-arthritis.
FIG. 3b.—(Case III.) The hip eight and one-half years after a Whitman's reconstruction operation.

was obtained. She was shown at the International Congress of Orthopædic Surgery in London, 1933, eight and one-half years after operation, with a free range of movement, no limp or Trendelenburg gait. This is the best result we have obtained, possibly due to the length of the neck and the age of the patient. This end-result is better than an arthrodesis, but is exceptional. We cannot be sure that other patients will end up as well, hence we advise arthrodesis for the average case.

CASE III.—Illustrates the use of a reconstruction operation as an alternative to arthrodesis in an old man (Figs. 3a, 3b, 4a and 4b). *Result.*—Very good function in spite of being

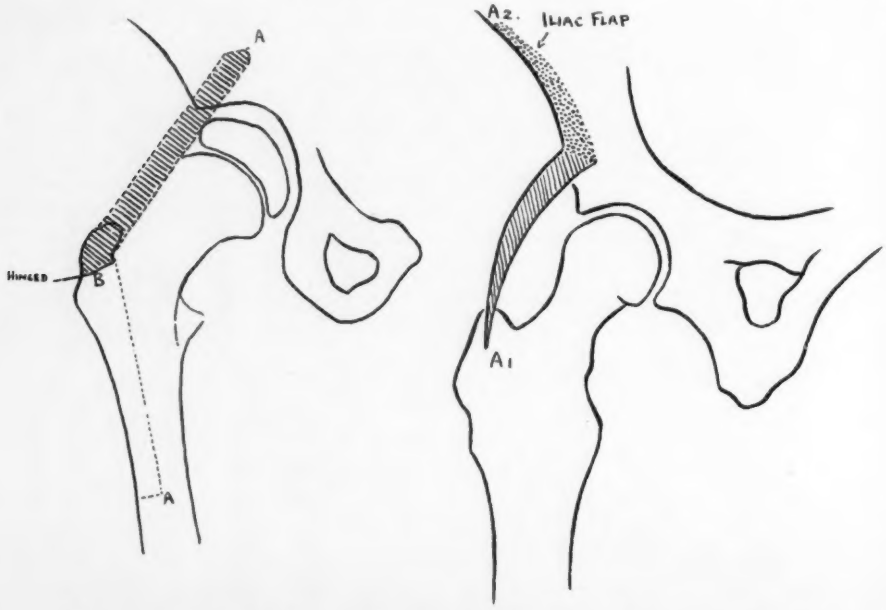

FIG. 4a.—(Case III.) Diagram showing an extra-articular tibial or femoral graft.
FIG. 4b.—(Case III.) Diagram showing an extra-articular iliac or osteogenic flap.

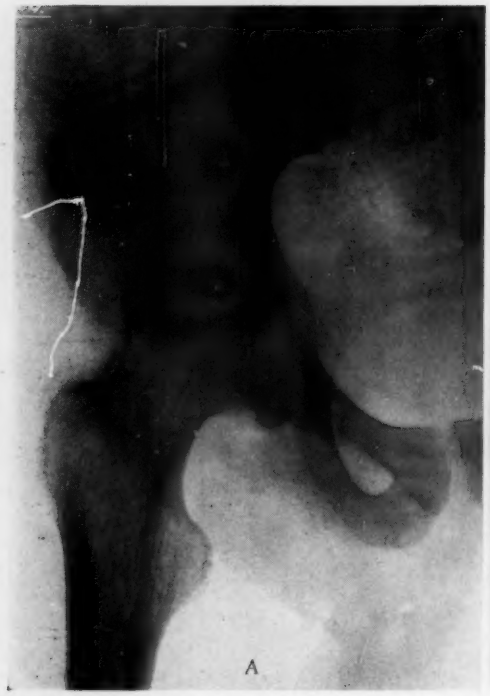

FIG. 5a.—(Case IV.) The hip-joint eight months after a streptococcal arthritis.

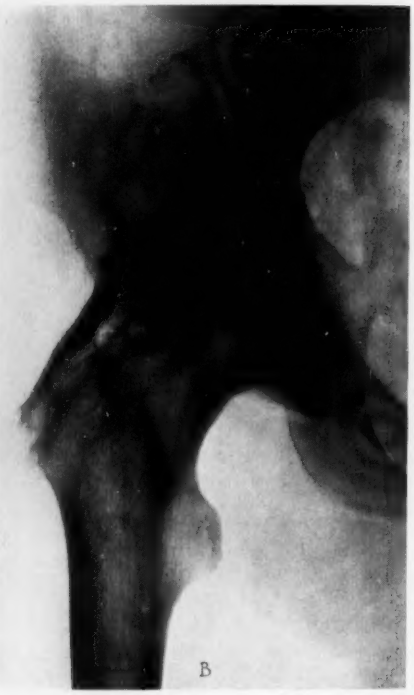

FIG. 5b.—(Case IV.) The tibial graft in place, one year after operation.

seventy-two years old. The man is earning his living by cleaning cars and is able to drive a lorry.

CASE IV.—Illustrates the use of an arthrodesis of hip for an unsound ankylosis, following acute infective arthritis (Figs. 5a and 5b). *Result.*—The hip is firmly fused and the function is very good, the patient being able to run and take an active part in most games and even to skate, three years after the operation.

CASE V.—Illustrates the use of an extra-articular graft, combined with an osteotomy to correct fixed deformity (Figs. 6a and 6b). *Result.*—In spite of the fact that fusion was obtained in good position, the result is of doubtful value as the patient complained of disability in her knee which was unstable as a result of a long period of weight-bearing in a faulty position, previous to operation. The disabling tendency of poor knee function is a point in favor of early operation when fixed deformity is present.

CASE VI.—Illustrates the use of a fixation operation for a painful hip following trauma (Figs. 7a and 7b). *Result.*—The pain is cured and the function excellent.

CASE VII.—Illustrates the use of a graft in an old woman (Figs. 8a and 8b). *Result.*—The patient made a splendid recovery and was cured of all pain.

CASE VIII.—Illustrates the use of the iliac flap method in tuberculous arthritis of the hip (Figs. 9a and 9b). *Result.*—Solid union in good position.

Remarks.—In our experience intra-articular fusion will follow in course of time and the prognosis as regards the hip is assured.

CASE IX.—Illustrates the use of an extra-articular graft in the treatment of grumbling tuberculous arthritis (Figs. 10a and 10b). *Result.*—Some shortening is present from the old destruction of the head and epiphysial line by disease, but the hip is firmly fused, and a painless hip soundly ankylosed is the result.

Remarks.—In spite of rest, immobilization and constitutional treatment, the disease had progressed, leading to complete destruction of the head and enlargement of the acetabulum. We expect no return of symptoms and in our experience the hip is not likely to give further trouble.

RESULTS.—ARTHROPLASTIES.—We have followed up the results of forty-two operations. There was one death from pulmonary embolism. From the point of view of the patient, there were six failures—that is, the pain was unrelieved. The remaining thirty-five were benefited, they lost their pain, and had some range of active movement in the joint. In five of these, the stump of the neck had dislocated out of the acetabulum. This would seem to cause no disability—*i.e.*, no pain, but added to the shortening and to the dip in walking.

Although in this series the functional result from the patient's point of view has been fairly satisfactory and the pain is relieved, yet when critically examined—with a few brilliant exceptions—the range of movement is small and the dip on walking is marked. The important factor is not the range of movement obtained, but rather the restoration of abduction and extension, that is, the normal weight-bearing position of the hip; so that the patient stands without constantly producing strain on the joint and a stretching of the capsule.

On the whole, the results as seen some years after operation were better than I had supposed, considering the age of the patients—twelve were between fifty and sixty years, eleven over sixty, and one over seventy. My impression

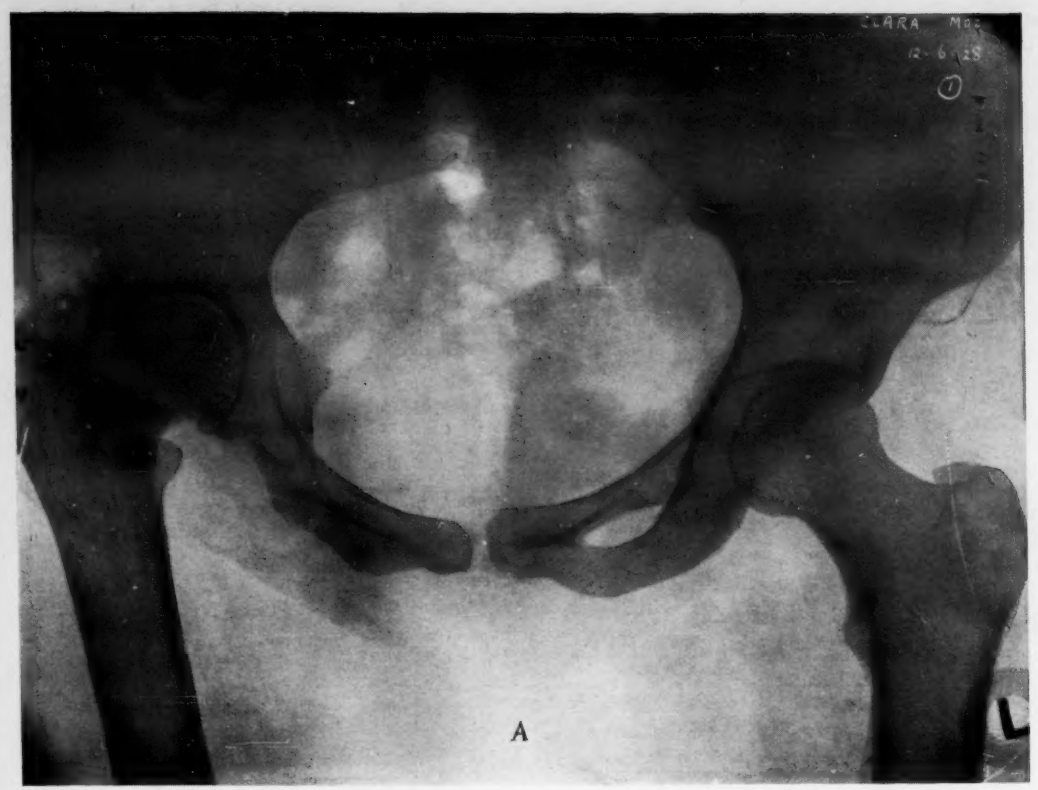

FIG. 6a.—(Case V.) A chronic arthritis of the hip in a woman of twenty-six years, with nine years history of pain and disability. An old, infective arthritis of unknown origin.

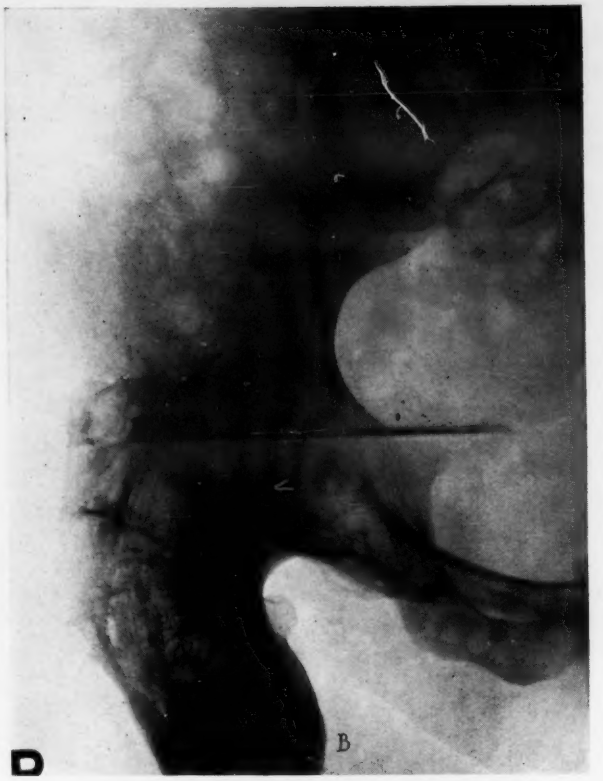

FIG. 6b.—(Case V.) Intra- and extra-articular fusion four and one-half years after operation.

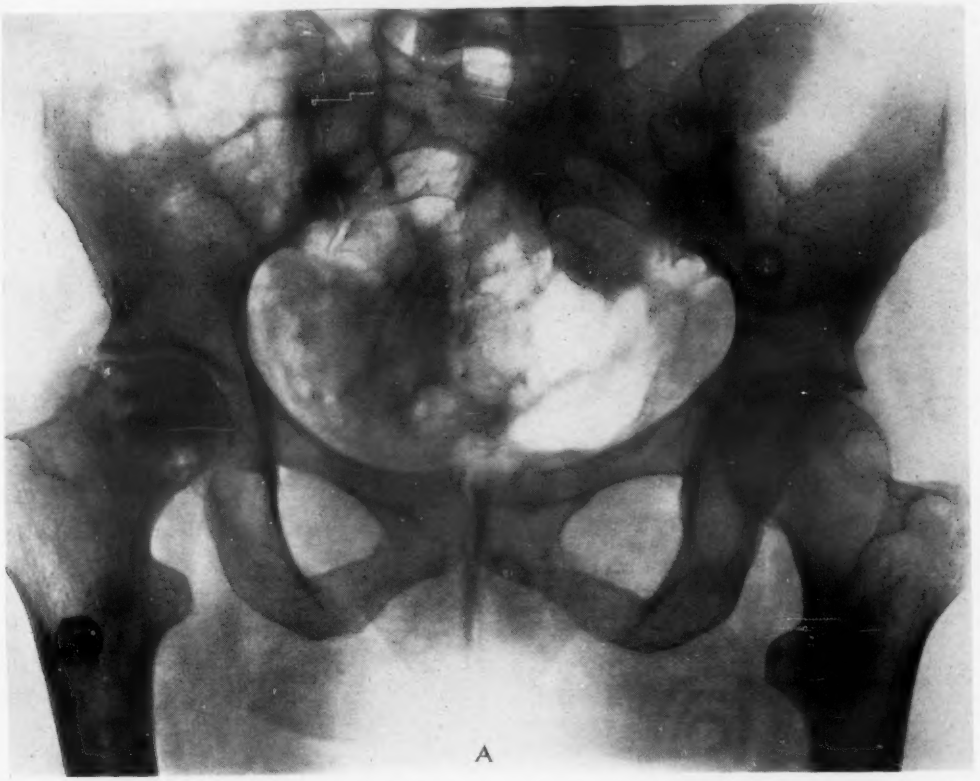

FIG. 7a.—(Case VI.) Case of a painful hip following a subcapital fracture one year and eight months previously.

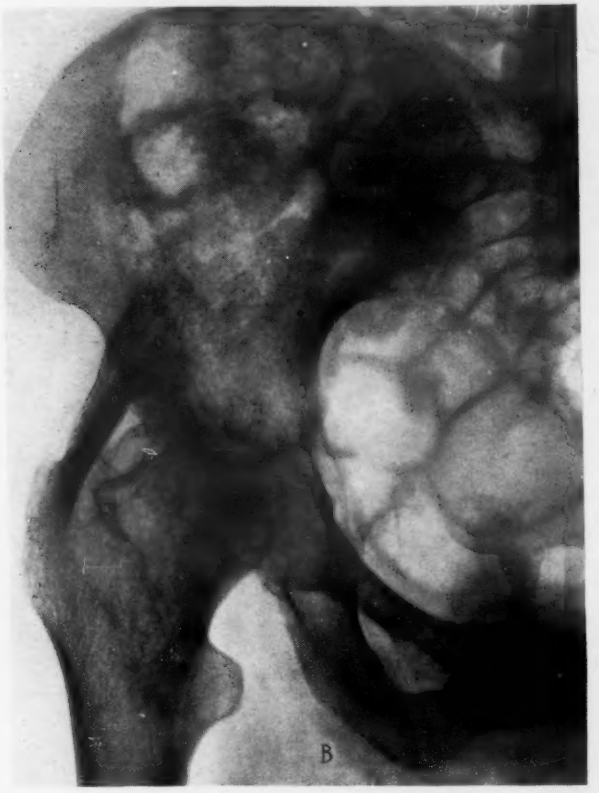

FIG. 7b.—(Case VI.) The result of the combined operation with an osteogenic flap. This X-ray was taken six months after operation and shows the rapid consolidation of the osteogenic flap.

is that arthroplasty, or Whitman's reconstruction, is to be regarded as the operation of choice for the old un-united fracture of the neck of the femur, and for chronic arthritis, when both hips or the hip and knee on the same

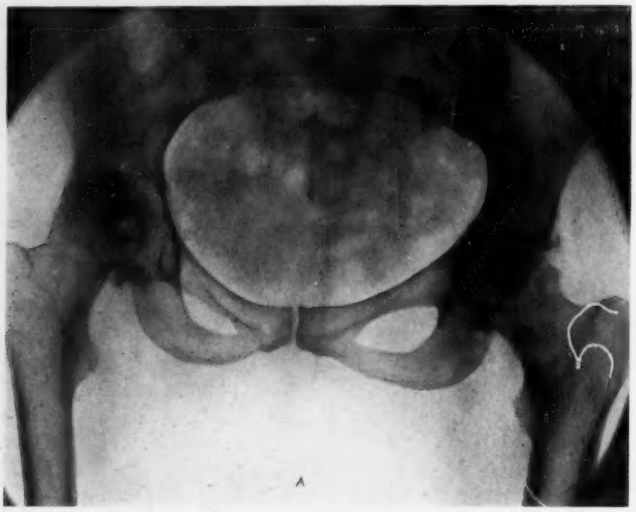

FIG. 8a.—(Case VII.) An arthritis of the hip in a woman aged seventy-two years, after eighteen months of conservative treatment had failed to relieve the pain, compelling operative interference in spite of her age.

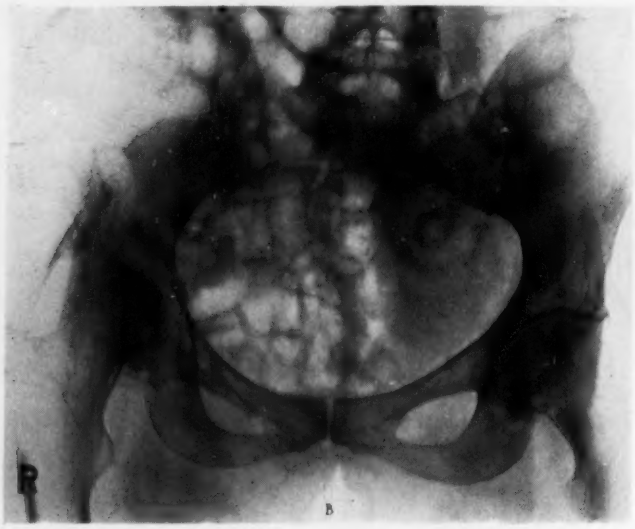

FIG. 8b.—(Case VII.) The result of the combined arthrodesis six months after operation. The iliac flap does not show very clearly in the X-ray, but the appearance suggests intra-articular fusion, as well as a viable graft.

side are stiff. Arthroplasty should not be undertaken for infective arthritis, unless one is definitely certain that the disease has burnt itself out, and there is no risk of lighting up latent infection. Consideration of theoretical mechanics alone is not enough upon which to base the operative prognosis.

ARTHRODESIS.—One hundred and one patients upon whom this was per-

formed were examined. Fifty-six of these were non-tubercular arthritis and forty-five tubercular. Of the non-tubercular cases thirty-seven had obtained stable hips; twenty-four had X-ray evidence of bone fusion; and in thirteen there was a sound ankylosis, although the X-ray proof was lacking.

Eighteen resulted in fibrous union—*i.e.*, nearly 33 per cent. still had mobility in the hip. Although this means failure from the point of view of the surgeon, it is not necessarily failure from the patient's viewpoint. One boy, for example, in whom we failed to secure fusion, has been for some years now earning his living at work driving a van. We may fairly claim that the operation—even if there is failure of bone fusion—relieves the pain in the great majority of patients. It is perhaps interesting to speculate as to

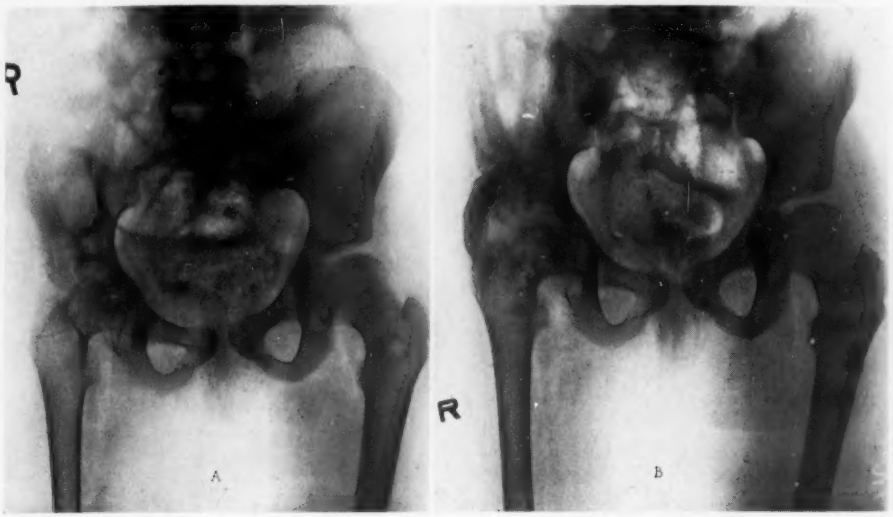

FIG. 9a.—(Case VIII.) Tuberculosis of the hip (proven) of three years' duration in a girl aged ten years.
FIG. 9b.—(Case VIII.) The osteogenetic iliac flap consolidating, six months after operation.

why this occurs. I suspect it is largely a question of alteration in the joint capsule, and that the vascularity of the capsule and subsequent fibrosis is markedly changed by the operative exposure, but I must add that in spite of repeated attempts, we can produce no microscopical evidence that this explanation is correct.

Persistent stiffness in the knee is sometimes troublesome, but pain in the lumbar spine has been less in evidence than one would have supposed and tends to lessen with time. The added strain thrown on the lumbar spine is an academic argument against arthrodesis, but we must remember that the hip has already been stiff, that it has had a limited range of movement through a useless arc, generally for some years, and that the spine has already to some degree accommodated itself.

The maximum benefit is not usually attained for from one to two years after operation. Convalescence is prolonged.

Arthrodesis is the method of treatment by which we can definitely stop the pain in the hip-joint and predict a previously estimable degree of function. In tubercular patients it is difficult to ensure bone fusion, which is after

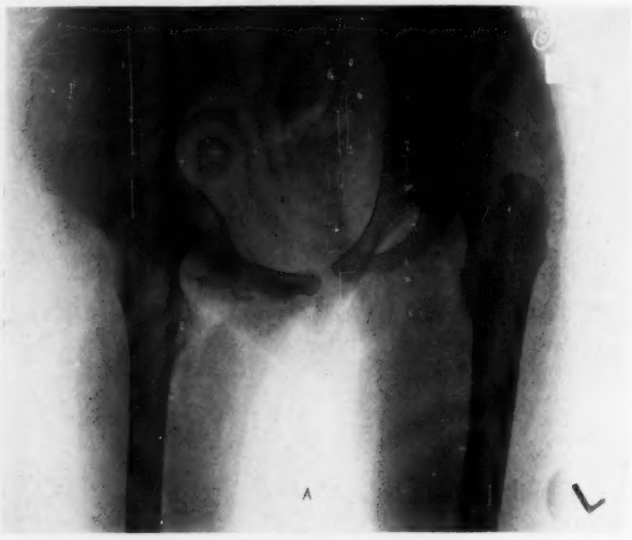

FIG. 10a.—(Case IX.)) An involved right hip following five years' conservative treatment for tuberculosis.

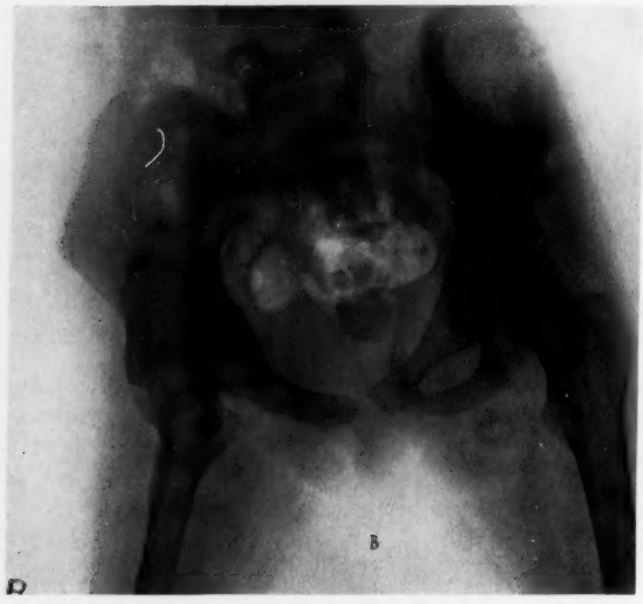

FIG. 10b.—(Case IX.) The graft four and one-half years after operation, solidly fixed. The graft was taken from the femur and an osteotomy to correct adduction performed at the same time.

all what we should expect in a disease in which the essential pathology is bone destruction without new bone formation. We believe that if there be

destruction of articular cartilage, there comes a time in tuberculous arthritis when arthrodesis is called for.

Of the forty-five attempted arthrodeses, there were no deaths. Bone fusion occurred in eighteen, failed in twenty, and is as yet uncertain in seven. The failures can be in part explained by errors of technic noticeably in the earlier cases, and by operating too early, when disease is still active and spreading, and therefore the graft is inserted into unhealthy host bone.

Of the total 143 cases; twenty-seven, *viz.*, five arthroplasties and twenty-two arthrodeses were under the care of my colleague, Mr. Max Page, who kindly gave me the details which were worked out by Mr. N. R. Barrett. The remaining 116 were treated in the Orthopædic Department at St. Thomas' Hospital or privately. My thanks are due to my colleague, Mr. George Perkins, and to my assistants, Mr. Butler and Mr. Furlong, for kindly preparing the notes and looking up the necessary X-rays and records, which have made this survey possible.

DISCUSSION.—DR. DALLAS B. PHEMISTER (Chicago).—I am interested to know that Mr. Bristow has had successful results following arthroplasty for chronic arthritis of the hip, since my own limited experience with the operation has not been satisfactory. I heartily endorse all that he said about arthrodesis for the conditions which he mentioned and have gone further to include chronic arthritis and some cases of old, un-united fracture of the neck of the femur with necrosis of the femoral head. In tuberculosis of the hip we have had failures from use of inlay grafts and it is now our practice to employ two broad whole thickness grafts from the tibia to bridge the joint. In cases of inadequate hips from defective acetabulum and congenital dislocations of the hip in which it is impossible to restore the head to acetabulum, we have shelved the femoral head by the use of three broad tibial peg grafts inserted above it into deep grooves from a hemihexagon. When the grafts are driven into the ilium they are firmly fixed and give adequate support with a brief post-operative period of immobilization.

DR. JAMES MORLEY HITZROT (New York).—I was very glad to hear Mr. Bristow's presentation because in twelve experiences with arthroplasty on the hip the problem of pain after the arthroplasty was one that interested me. These were all in individuals under thirty years who had disabled hips. The problem of pain after the arthroplasty in six of those cases interested me particularly. There were six that I could regard as satisfactory from the patient's standpoint; that is, they had a hip in which the motion and the weight-bearing were correct. In the other six there were difficulties of all kinds, of which pain was the essential feature.

I wanted to ask Mr. Bristow whether he thought that that had anything to do with the way you handle the synovial portion of the joint; whether the problem is something like the problem of pain of bursæ, where if parts of the synovial membrane have been left in or near the articular pressure points that pain persists.

We have made sections from the specimens removed from the synovial membrane and tried to stain them in some way to bring out the question of nerve fibrils and have been unable to prove anything. I mean, the histology is the histology of a productive connective-tissue process with hypertrophy of the synovial folds and infiltration of plasma cells and round cells, but we have been unable to demonstrate in those sections any nerve fibrils which would explain the pain.

That has been a real problem in my experience, and in two of those cases I subsequently did an arthrodesis because of the pain. I think the arthroplasty failed.

I am very much less anxious to do arthroplasties in the hips now. The fact that the

first three cases were the most successful ones and the last six were unsuccessful was very discouraging.

Mr. W. Rowley Bristow (London, England).—The only thing I would say to the last speaker is that my experience agrees with his, and that I do not think you can be sure of your result in an arthroplasty of the hip-joint.

I should need much more information as to what the pre-operative state of the patients to whom he is referring was, before being able to offer any suggestions for the solution of the problem.

I am quite sure that we always fail if there is an active infective process, and we have great difficulty in deciding when the infection has quieted down sufficiently. I think you can predict the result of arthrodesis; I do not think you can predict the result of arthroplasty. Therefore, as I tried to make clear, we reserve arthroplasty for a patient in whom there is a definite indication that you cannot afford to fix the hip on that side.

In one or two early cases in which we had some success, we were trying out to see whether or not we could get away with a movable hip with the same degree of safety. For myself, if I had my hip-joint affected and chronically painful, I would have my hip arthrodesed if it failed to respond to symptomatic treatment.

ANTEROTHORACIC ŒSOPHAGOPLASTY FOR IMPERMEABLE STRICTURE OF THE ŒSOPHAGUS

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The ideal method of replacement of an obstructed thoracic œsophagus would probably be the removal of the diseased portion and the reconstruction of the œsophagus in the posterior mediastinum. Unfortunately, such operations are attended with an extremely high mortality and, therefore, are not feasible or justified. Formerly, reconstructive œsophageal surgical procedures were limited to the cervical portion of this viscus, which could be relatively easily attacked. Not until H. Bircher's attempt on May 21, 1894, to circumvent a carcinoma obstructed œsophagus, by the formation of a tube from the skin on the anterior surface of the thorax, was any progress made concerning the reconstruction of an obstructed thoracic œsophagus. The death of Bircher's first patient from a pulmonary embolism did not permit him to complete the operative procedure. The case demonstrated that the reconstruction of an œsophagus from skin was feasible (Fig. 1). In a second patient, also with carcinoma, the skin tube was satisfactorily formed and as in the first case sutured to the stomach. This patient, too, died before the operation could be completed. Since the original observations of Bircher,[1, 2] numerous attempts have been made according to various technics to reconstruct an extrathoracic œsophagus. Wullstein,[3] in 1904, based upon cadaveric dissections, suggested using a loop of jejunum for the reconstruction of the œsophagus. This he did by dividing the jejunum a short distance distal to the duodenojejunal junction. The proximal end he anastomosed to the distal portion about 20 to 30 centimetres below the division. The mobilized loop was brought up with the mesentery attached through the transverse mesocolon, the lesser sac, and the gastrocolic omentum to lie anterior to the stomach. The loop was brought anterior to the thorax under the skin. As a third stage, he suggested the reconstruction of a skin tube according to the technic of Bircher and a final anastomosis with the cervical œsophagus. In this way the food passing through the new œsophagus would not enter the stomach, but would empty directly into the jejunum. Roux,[4] in 1907, published the results of the first successful anterothoracic œsophagoplasty, which he performed in a child suffering with a benign stricture of the œsophagus. The procedure which he used differed from that suggested by Wullstein in that instead of a Y-anastomosis, he mobilized a free loop of bowel, anastomosed oral and aboral ends of the non-mobilized jejunum, and brought the jejunal loop and attached

mesentery which was partially divided to allow freer mobilization around the transverse colon. The aboral end of the mobilized segment was anastomosed by an end-to-side anastomosis with the anterior surface of the stomach similarly as in a Tavel gastrostomy. The oral end of the mobilized segment, after tunneling under the skin of the anterior thorax up to the suprasternal notch, was placed subcutaneously anterior to the thorax. At a subsequent operation after the jejunal loop had been shown to be viable, an astomosis between the cervical œsophagus and the jejunal loop was accomplished. In 1911 Hirsch,[5] on the basis of observations made on cadavers and dogs, suggested that a gastric tube formed from a flap prepared from the anterior surface of the stomach be used in the construction of an anterothoracic œsophagus. He felt that such a tube would have the distinct advantage over a cutaneous tube in that the former would possess peristaltic movement. Shortly after this, in 1912, Jianu[6] described a method of œsophagoplasty which had been previously suggested as a method of gastrostomy by Carl Beck[7] (Fig. 1). This consisted of the formation of a tube from the greater curvature of the stomach. Concomitant with Jianu, Halpern[8] suggested the formation of a gastric tube from the greater curvature of the stomach and his technic differed from that of Jianu only in that he used curved clamps. He stated that in the normal cadaver, the new œsophagus could be made to extend up to the neck and that if the lowest costal cartilages 4 centimetres from the sternal attachment be resected, it could be brought up to the edge of the thyroid cartilage. He was successful in performing such an œsophagoplasty in dogs. In the same year, Fink[9] reported a case in which he had performed an anterothoracic œsophagoplasty, using the stomach for the new œsophagus. He divided the duodenum at the junction of the horizontal and vertical portions, freed the stomach of its attachments except at the cardiac end, and placed the mobilized viscus beneath the skin of the anterior thorax, following which a posterior gastroenterostomy was done. The operation was completed by constructing a skin tube extending from the upper end of the duodenum to the suprasternal notch. At a second stage the cervical œsophagus was mobilized and divided transversely. The upper end was anastomosed to the skin tube. Following this, the patient was able to swallow, but died within a few days as a result of perforation of the carcinoma at the cardia of the stomach. Kirschner[10] (1920) also used the mobilized stomach for the reconstruction of the œsophagus, but his technic differed from that of Fink in that the stomach was divided immediately below the cardia and after being mobilized was brought up through a subcutaneous tunnel anterior to the thorax in an isoperistaltic manner. The lower end of the œsophagus was anastomosed with the jejunum by means of a Murphy button. The mobilized stomach, after division of its mesenteric attachments along the lesser and greater curvatures, could be drawn out into a long tube and made to reach up the cervical region. In this way a tube placed isoperistically, one well supplied with blood and one long enough to reach to the cervical region without an intervening portion of skin could be formed (Fig. 1). In 1911, Kelling[11] in a forty-five-year-old woman

with a carcinoma of the œsophagus performed a two-stage œsophagoplasty using the transverse colon. The distal end of the mobilized segment was anastomosed to the stomach, whereas the proximal end was brought up through a

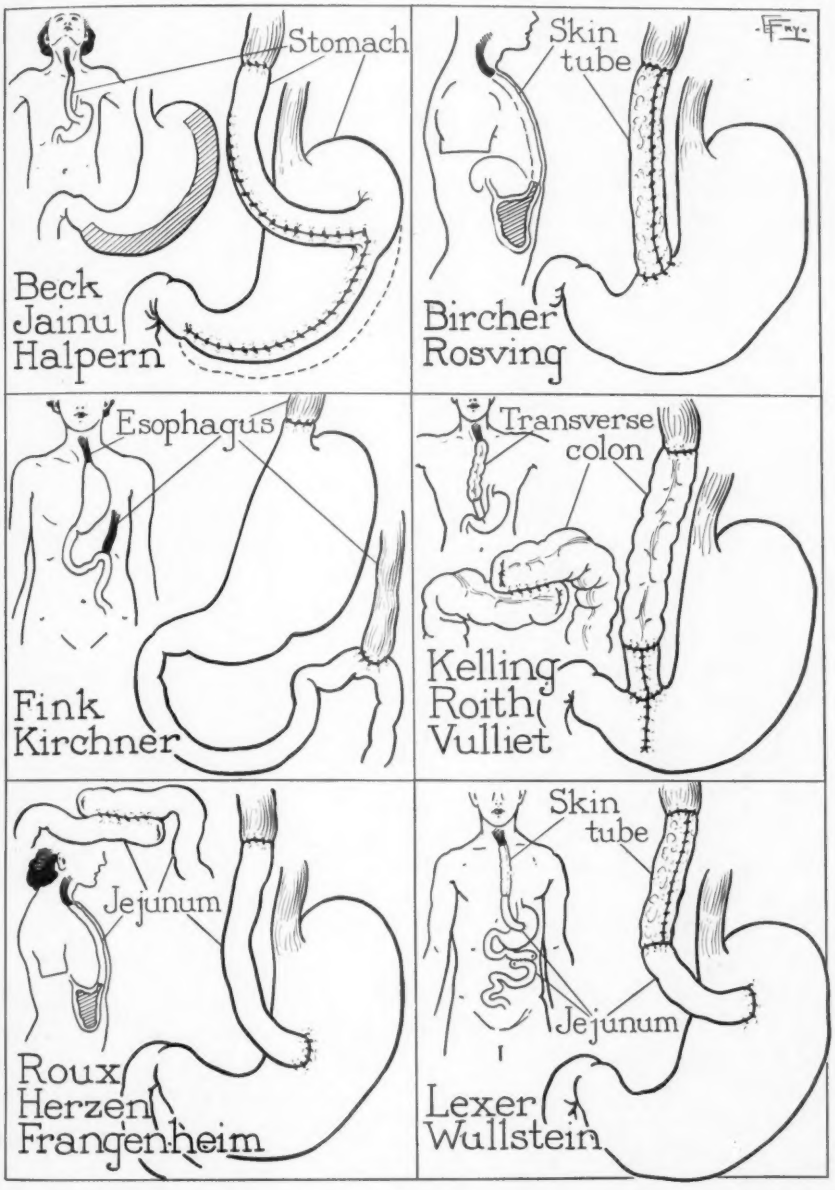
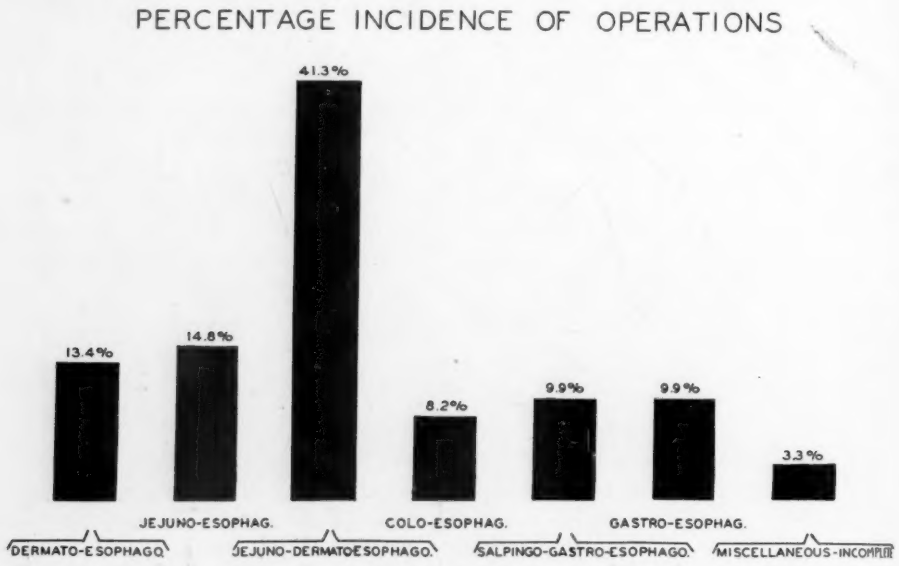


FIG. 1.—Diagrammatic drawing showing the various types of anterothoracic œsophagoplastic operations.

subcutaneous tunnel to the level of the nipple. Three weeks later the cervical œsophagus was mobilized and sutured to the cervical fascia below the skin, and a skin tube was formed between the œsophageal fistula and the opening in

the transverse colon. An anastomosis between the œsophageal fistula and the upper end of the skin tube was never accomplished, because the patient died of a carcinoma before this could be done. Modifications in the technic of colo-œsophagoplasty have been made by Vulliet and Roith[12] as follows: The former used a loop of transverse colon antiperistaltically, whereas the latter used the cæcum, ascending colon, and the right half of the transverse colon as a tube for the reconstruction of the œsophagus. A modification in the construction of a skin tube in an œsophagoplasty was suggested by Esser,[13] which consisted of lining a tunnel under the skin of the thorax with inlay Thiersch grafts placed on a "stent." He hoped to make the operative procedure simpler than construction of the skin tube according to the technic of Bircher and described two cases in which it was done.



GRAPH I.—Graph showing the percentage incidence of various operations used in performing the anterothoracic œsophagoplasty.

The various operative procedures employed in the reconstruction of an anterothoracic œsophagus may be classified as follows: I. Dermato-œsophagoplasty, use of skin alone: (A) Full thickness skin (Bircher). (B) Thiersch inlay grafts lining skin tunnel (Esser). II. Jejuno-œsophagoplasty, use of small bowel alone: (A) Mobilization of jejunal segment anterior to transverse colon (Roux). (B) Mobilization of jejunal segment through lesser sac (Herzen).[14] III. Jejuno-dermato-œsophagoplasty, use of small bowel and skin tube: (A) Y-anastomosis of jejunum (Wullstein).[15] (B) Jejunal segment anastomosed to stomach (Lexer).[16, 17, 18, 19] IV. Colo-œsophagoplasty: (A) Transverse colon, (1) isoperistaltic (Kelling); (2) antiperistaltic (Vulliet). (B) Ascending colon (Roith). V. Gastro-œsophagoplasty: (A) Salpingo-gastro-œsophagoplasty. Formation of tube from stomach, (1) from greater curvature (Beck-Jianu-Halpern); (2) from anterior surface

(Hirsch). (B) Gastro-œsophagoplasty, use of entire stomach, (1) antiperistaltically (Fink); (2) isoperistaltically (Kirschner).

Our interest in œsophagoplasty was stimulated by a case which we have had, a report of which will be included in this presentation. In order to evaluate the various operative procedures, we have reviewed all of the cases in which an anterothoracic œsophagoplasty has been reported up to the present time. Unfortunately, many of the reports are incomplete so that little could be gotten from the case except the type of operation and possibly the end-results. As many of the cases were operated upon in Russia and reported only in the Russian language great difficulty was encountered in obtaining accurate data. The majority of patients have been operated upon in the German, Austrian, Russian, and Scandinavian clinics. Relatively few have been operated upon in the English-speaking countries, particularly America. As a matter of fact, there is at the present time no case on record of a completed œsophagoplasty having been performed in America. The present study is based on an analysis of 240 cases in which œsophagoplasty was done for either benign or malignant strictures. In these 240 cases, 242 types of operation were used, the discrepancy between the number of cases and the types of operation being due to the fact that in two cases two types of operations were used, one failing and the surgeon resorting to another procedure before obtaining satisfactory results. In one of these patients Rehn[20] originally produced a Jianu gastric tube. Because, however, of the complete digestion of the gastric tube and the surrounding skin, it was subsequently necessary to mobilize a loop of jejunum and this together with a skin tube to reconstruct an œsophagus. The other case in which a second type of operation was necessary was reported by Hübler[21] in 1928. Originally a jejuno-dermato-œsophagoplasty was performed, but because of the development of a peptic ulcer in the jejunal loop, it became necessary to resect the loop and replace it with a segment of transverse colon. Of the 242 operations performed in the 240 patients the operative procedure employed was as follows (Chart I):

CHART I

Type of Operation	Number of Cases	Percentage of Whole
Dermato-œsophagoplasty	32	13.4
Jejuno-œsophagoplasty	36	14.8
Jejuno-dermato-œsophagoplasty	100	41.3
Colo-œsophagoplasty	20	8.2
Salpingo-gastro-œsophagoplasty	24	9.9
Gastro-œsophagoplasty	22	9.1
Miscellaneous and incomplete	8	3.3

DERMATO-ŒSOPHAGOPLASTY.—Of the thirty-two cases in which only skin was used to reconstruct the œsophagus, thirty were operated upon according to the technic of Bircher: *i.e.*, a tube was formed from the skin of the anterior thorax by making parallel incisions approximately 6 to 8 centimetres apart extending from the cervical to the epigastric regions. The edges of the flaps

so formed were mobilized and sutured in such a way that the cutaneous surface formed the lining of the tube. Over this lateral skin flaps were mobilized to cover the newly formed skin tube (Fig. 1). In two of the thirty-two cases the skin tube was constructed according to the technic of Esser: *i.e.*, a subcutaneous tunnel was lined with Thiersch inlay grafts. In the group of thirty-two patients there were ten males and eleven females, whereas in eleven the sex was not stated. The cause of the œsophageal obstruction was cicatricial stenosis following ingestion of lye in eleven cases, hydrochloric acid in three cases, acetic acid, and sulphuric acid, each one case. Carcinoma was the cause of obstruction in two cases, whereas in fourteen the cause of obstruction was not stated. In twenty in which the age was given the oldest was fifty-five, the youngest six, and the average 24.2 years. Of the ten in which lye was the cause of obstruction in which the age was stated, the oldest was forty-two, the youngest six, and the average 22.9 years. Of the two patients with carcinoma, in only one was the age stated (forty-one years). Of the twenty cases in which the number of operations employed was stated, the largest number in any one case was eight, the least was one, and the average, 4.5 operations. The longest duration in the fifteen in which this was stated was eleven years, the shortest eight months, and the average 3.8 years. Of the thirty-two patients operated upon, twenty-one (70 per cent.) recovered, nine (30 per cent.) died. In two the result was not given. The operation was completed in nineteen (53.3 per cent.) of the patients, not completed in eleven (33.6 per cent.). In two no statement was made concerning completion. In twelve the function was classified as good, in two as fair, and in one as poor. In six it was not stated. The fourteen cases in which good or fair results were obtained represent 46.6 per cent. of all the cases operated upon, and 73.6 per cent. of those in which the operation was finished. The reconstruction of the œsophagus from skin alone has many advantages and disadvantages. An important advantage is that a minimal amount of intraperitoneal manipulation is necessary, whereas the mobilization of a segment of small or large bowel is a much more formidable procedure. Another advantage is that the entire skin tube can be made in one stage, shortening the hospitalization considerably. On the other hand, a distinct disadvantage of the dermato-œsophagoplasty is the danger of digestion of the skin tube by gastric contents because of the direct anastomosis of the lower end of the skin tube with the stomach. The vulnerability of the skin tube is illustrated by the number of complications in the group of thirty-two in which a dermato-œsophagoplasty was done. In eleven it was not stated whether any complications were present. Fistulæ, either single or multiple, occurred in eighteen instances, pneumonia in three, gangrene of the œsophagus in one, gangrene of the skin tube in one, infection in one, and an embolism in one. Another proposed disadvantage of the skin tube, which, however, has not been substantiated, is that the skin tube cannot function as well as bowel because it lacks peristalsis. Schreiber[22] fluoroscopically demonstrated in patients operated upon by Lexer and Frangen-

heim[23, 24, 25, 26] that ingested contrast substances passed more rapidly through the skin tube than through the jejunal tube. Zaaijer[27, 28, 29] has also corroborated this finding. The passage of substances through the skin tube which obviously lacks peristaltic movement is the result of the squirting action of the pharynx, which could be readily demonstrated in our case before the skin tube was anastomosed with the jejunal tube (Fig. 2). Repeatedly we have been able to demonstrate that concomitantly with the act of swallowing water would be forcefully ejected from the lower end of the skin tube. That gravity is not necessary for the passage of food through the newly formed œsophagus has been shown röntgenologically by Frangenheim and Sampson,[30] the former observing that the contrast substance passed through the œsopha-

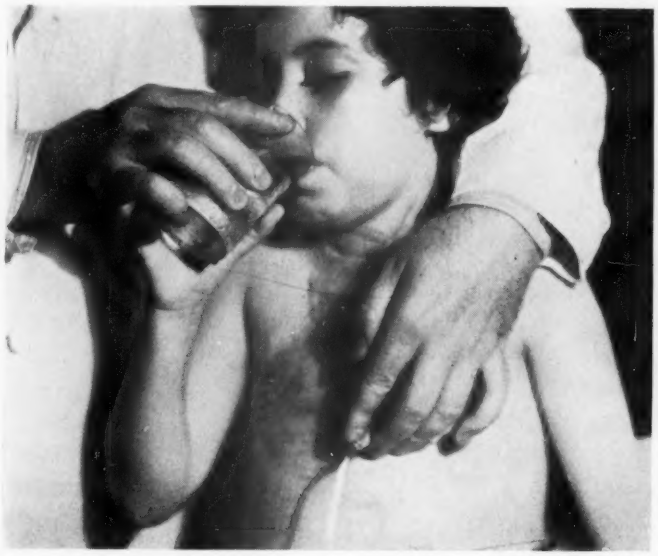


FIG. 2.—Photograph showing patient swallowing water, demonstrating its passage through the cervical œsophagus and out through the skin tube portion. A rubber tube has been inserted in the lower portion of the skin tube in order to facilitate the passage of the water and to make it more demonstrable for photography.

gus with the patient in the horizontal position, whereas the latter demonstrated that the contrast substance passed through the œsophagus with the patient even in the inverted-head position.

JEJUNO-ŒSOPHAGOPLASTY.—Thirty-six (14.8 per cent.) of the œsophagoplastic operations were performed by using only a loop of jejunum in the reconstruction of the œsophagus (Fig. 1). In this group there were twelve males and nine females, whereas in fifteen the sex was not stated. The etiology was as follows: Cicatricial stenosis following lye, seven cases; ammonia, sulphuric acid, acetic acid, hydrochloric acid, and silver nitrate each one case; benign stricture, the cause of which was not stated, four cases. In ten cases the cause of the obstruction was carcinoma. One case followed an œsophageal fistula after an empyema and in nine the cause was not stated.

Of the eighteen in which the age was stated the oldest was sixty-one, the youngest six and one-half, and the average 36.3 years. Of the seven cases which followed lye ingestion, the ages were given in five; the oldest was thirty-five, the youngest six and one-half, and the average 20.7 years. Of the ten cases in which carcinoma was the cause of obstruction, the ages were given in only three, the oldest being sixty-one, the youngest forty-eight, and the average 54.3 years. In the twenty-three cases in which the number of operations performed was stated, the largest number was six, the least number one, and the average 2.2 operations per patient. In eighteen the number of operations was not stated. There was considerable variation in the duration of symptoms before operation, the longest ten years, the shortest four months, and average 1.8 years. In twenty-six cases the duration of symptoms was not stated. Of the thirty-six cases, sixteen recovered, fourteen died, whereas in six it was not stated whether recovery occurred. Of the thirty in which the result was given, 53.3 per cent. recovered and 46.6 per cent. died, an almost prohibitive mortality rate. Of the thirty-six cases, in six it was not stated whether the operation was completed. Of the remaining thirty, thirteen (43.3 per cent.) were completed, whereas seventeen (56.6 per cent.) were incomplete at the time of the report. In twelve cases it was stated that the function was good, giving a ratio of 40 per cent. of all the cases started and 92.3 per cent. of those completed. The greatest number of complications (eight) consisted of interference with the circulation of the mobilized segment of bowel resulting in gangrene. Peritonitis was present in five; single or multiple fistulæ in six; stenosis in two; pneumonia, mediastinitis, regurgitation of the gastric contents, each in one case. In sixteen cases it was not stated whether there were any complications. The high incidence of gangrene of the jejunal loop was undoubtedly due to the fact that in order to secure a sufficiently long segment of jejunum to extend up to the cervical region and in order to complete the œsophagoplasty without an intervening portion of skin, the blood supply of the loop was jeopardized. In order to secure sufficient mobilization of the jejunal loop it is almost invariably necessary to divide the mesentery in its proximal portion as first recommended by Roux. As suggested by Blauel,[31, 32, 33] one should determine, before cutting the root of the mesentery, the viability of the proposed jejunal segment by compressing the vessels which are to be divided. The mobilized segment of gut in such an instance would receive its blood supply from the remaining branch or branches of the superior mesenteric vessels and the marginal vessels. In order not to interfere with the marginal vessels the incision in the mesentery must be made close to the root and at some distance from the bowel. Ritter and von Haberer have emphasized that the length of intestine which may be divided depends entirely upon the number of vessels which are severed. Ritter[34, 35, 36] showed that if the mesentery is divided close to the gut, it is possible to mobilize the intestine for a distance of from 2 to 7 centimetres, whereas if it is divided at a considerable distance from the intestine, this length may be increased

to from 8 centimetres to 15 centimetres. The original proposal of Roux that the mobilized segment of jejunum be brought around anterior to the transverse colon, which was performed four times in the present collected series, should seldom be used because of the pressure exerted by the colon on the mesentery of the mobilized segment of jejunum. In these four cases complete necrosis of the tube occurred in two, partial necrosis in one, but in the fourth a good result was obtained. One of the advantages of an intestinal segment as compared with a skin tube for anastomosis with the stomach is the relatively greater immunity of the former to the action of gastric secretions. That an ulcer may occur in the mobilized segment of jejunum is evidenced by the case reported by Hübler,[37] in 1928, in which it was necessary to resect the jejunal loop because of a peptic ulcer which had developed. In this particular case the operation was completed by using a loop of transverse colon.

JEJUNO-DERMATO-ŒSOPHAGOPLASTY.—Lexer, realizing the danger of digestion of the skin tube by gastric contents when the skin tube was anastomosed directly with the stomach and also realizing the danger of necrosis of the distal portion of a segment of jejunum when too long a portion was mobilized, suggested combining a jejunal and a cutaneous segment (Fig. 1). The former, being anastomosed with the stomach, is more resistant to the gastric juice, whereas the length of the latter can be increased any amount without danger of jeopardizing the circulation. The procedure of jejuno-dermato-œsophagoplasty has undoubtedly been judged by the majority of surgeons as the method of choice, as the largest number of operations (100) have been done according to this technic. Of the 100 cases, there were twenty-nine males, thirty-six females, whereas in thirty-five the sex was not stated. The etiology in this group was as follows: stricture following ingestion of lye, forty-three cases; hydrochloric acid, five cases; sulphuric acid, formalin, ammonia, chloric acid, and congenital, each, one case. A benign stricture, the cause of which was not stated, occurred in six instances. The obstruction was carcinomatous six times and in thirty-five the cause was not stated. Of the fifty-six cases in which the age was given, the oldest was fifty-eight, the youngest three, and the average twenty-one years. Of the thirty-eight cases with lye stricture in which the ages were given, the oldest was forty-two, the youngest three, and the average nineteen and one-half years. Of the three cases of carcinoma in which the ages were given, the oldest was fifty-eight, the youngest forty-four, and the average forty-nine. Of the seventy cases in which the number of operations was stated, the greatest number was eight, the least, one, the average 4.3 operations per person. The duration of symptoms in fifty-one in which it was stated was as follows: the longest was seventeen years, the shortest two months, the average 3.2 years before the construction of the anterothoracic œsophagus. In twenty-one no statement was made concerning whether the patient recovered. Of the seventy-nine in which this information was given, sixty-one (78.4 per cent.) recovered and eighteen (22.7 per cent.) died. In only three of the 100 operations was there no state-

ment concerning whether the operation was completed. In the remaining ninety-seven the plastic was completed in sixty-four (65.3 per cent.) and not completed in thirty-three (35 per cent.). The results were classified as good in forty-six (47.4 per cent.) of all cases started and 97.8 per cent. of those in which the operation was completed. The complications encountered in the 100 jejuno-dermato-œsophagoplastic operations were as follows: fistulæ, single or multiple, thirty-nine; stenoses, seventeen; gangrene of the jejunum, nine; necrosis of the skin, six; infection, eight; pneumonia, five; regurgitation of gastric contents, five; dilatation of the jejunum, two; peritonitis, two; ulcer of the jejunum, empyema, perforation of a carcinoma into the bronchus, psychosis, necrosis of the œsophagus, dilatation of the stomach, cyst of the œsophagus, obliteration of the jejunum, inanition and diphtheria, each, one case. In thirty-three instances the presence or absence of complications was not stated. The danger of mobilizing a sufficiently long segment of jejunum to complete the œsophagoplasty and the comparative safety of employing a short cutaneous tube is shown by contrasting the complications in the two series of cases. In the jejuno-œsophagoplastic group of thirty-six cases, gangrene of the loop occurred eight times (22.2 per cent.), whereas in the jejuno-dermato-œsophagoplastic group (100 cases) this complication resulted in nine instances (9 per cent.). The comparative safety of the jejuno-dermato-œsophagoplastic operation is shown by the incidence of peritonitis in the two groups: 13.8 per cent. in the former and 2 per cent. in the latter. The relationship of the number of anastomotic sites to fistula formation is illustrated by comparing the jejuno-œsophagoplastic and the jejuno-dermato-œsophagoplastic groups. In the former, fistulæ developed in eight instances (16.6 per cent.), whereas in the latter, they occurred in thirty-nine instances (39 per cent.). This is undoubtedly due to the fact that in the latter group there were three sites of anastomosis instead of two. The occurrence of a fistula is undesirable, but seldom is there any real difficulty in closing it. The increased tendency toward fistula formation following a jejuno-dermato-œsophagoplasty is more than offset by the advantage that the mobilized segment of bowel has a greater chance of remaining viable and therefore the danger of peritonitis is less. The greater tendency for fistulæ to develop at a cutaneous anastomosis is demonstrated by comparing the incidence of fistulæ in the dermato-œsophagoplastic group with that in the jejuno-dermato-œsophagoplastic group. Of thirty-two dermato-œsophagoplasties, fistulæ developed in eighteen (56.2 per cent.), whereas of 100 jejuno-dermato-œsophagoplastic operations, fistulæ developed in 39 per cent. A disadvantage, both from the standpoint of the surgeon and the patient, in the jejuno-dermato-œsophagoplasty is the large number of operations required to complete the plastic. The average number of operations required per person in the jejuno-œsophagoplastic group was 2.2, whereas the average number required in the jejuno-dermato-œsophagoplastic group was 4.3. The number of operations required in the dermato-œsophagoplastic group was also high, five, probably because of the high incidence of fistula. In the jejuno-

œsophagoplastic group the mobilized loop of jejunum was brought through the transverse mesocolon, the lesser sac, and gastrocolic omentum, to its position in the upper abdomen, in nine instances, whereas in two instances it was brought anterior to the colon, as suggested by Roux. In the jejuno-dermato-œsophagoplastic group, the mobilized segment was brought through the lesser sac in forty-four and anterior to the colon in two.

COLO-ŒSOPHAGOPLASTY.—In twenty cases (8.2 per cent.) of the collected series, the colon was used in the reconstruction of the new œsophagus (Fig. 1). There were seven males, four females, and nine in which the sex was not stated. The cause of obstruction was as follows: Cicatricial stenosis following ingestion of lye, eight cases; stricture of unstated origin, two cases; potassium permanganate tablets, one case. In two cases the obstructing lesion was carcinoma and in seven the cause was not stated. Of the eleven in which the age was stated, the oldest was sixty years, the youngest four, the average 25.7 years. In the six cases of lye stricture in which the age was given the oldest was nineteen years, the youngest four, the average twelve years. In fifteen cases in which the number of operations was stated, the largest number was five, the least one, the average 2.8 per person. Of the twenty cases in which a colo-œsophagoplasty was done, the technic of operation was stated in twelve and not stated in eight. Of the twelve, in seven the transverse colon was used isoperistically (Kelling) and in four it was placed antiperistically (Vulliet). In one instance the æcum, ascending colon, and right half of the transverse colon were used for the formation of the œsophagus (Roith). This was successfully accomplished in one stage, the patient being able to eat on the eighth day and discharged seventeen days after operation. In ten cases in which the duration of symptoms before the beginning of the œsophagoplastic operation was stated, the longest was ten years, the shortest seven months, the average 3.1 years. As regards results, in two of the twenty cases no mention was made concerning the recovery. Of the remaining eighteen, fourteen (77.7 per cent.) recovered and four (22.2 per cent.) died. In two of the twenty cases, no statement was made concerning the completion of the operation. Of the remaining eighteen, the operation was completed in eleven (61.1 per cent.) and not completed in seven (38.8 per cent.). The end-results were termed as excellent in three, good in six, and fair in one, giving a total of 55.5 per cent. of fair to excellent results of all the cases in which the operation was started, and 90 per cent. good results in the cases completed. The complications consisted of fistulæ, single or multiple, seven; stenoses, three; infection, mediastinitis, gangrene of the œsophagus, each two cases; pouch in the colon tube, progression of carcinoma, progressive weakness, lobular pneumonia, peritonitis, leakage from a colocolostomy, and dilatation of the colon tube, each one case. The advantage of using a segment of colon in the reconstruction of the œsophagus is the ease with which a relatively long loop, the viability of which is quite definite, can be secured. As illustrated by Roith's case in which the entire œsophagoplasty was completed in one stage and the patient discharged seven-

teen days post-operatively, there is a great deal of merit in the procedure. One can hardly recommend, however, such a formidable one-stage procedure of mobilizing the ascending and right half of the transverse colon, reëstablishing the continuity of the bowel by an ileocolostomy, anastomosing the distal end of the mobilized segment to the stomach, extending the mobilized segment through a skin tunnel of the anterior thorax to the neck, freeing the cervical œsophagus and anastomosing it to the mobilized colon segment. The percentage of recoveries in this group was greater than any other group, almost identical with that in the jejuno-dermato-œsophagoplastic group, 77.7 per cent. and 77.2 per cent., respectively. In the jejuno-dermato-œsophagoplastic group, the incidence of the completed cases (65.3 per cent.) was somewhat greater than in the colo-œsophagoplastic group (61.1 per cent.). A good result was obtained in 55.5 per cent. of all the cases in which a colo-œsophagoplasty was attempted as compared with 47.4 per cent. in the jejuno-dermato-œsophagoplastic group. A distinct disadvantage in the use of the colon is the extremely slow emptying time, the ingested food remaining in it for long periods of time before entering the stomach. Von Hacker in one of his cases found that an hour after a contrast meal more barium remained in the colonic œsophagus than had passed into the stomach.

SALPINGO-GASTRO-ŒSOPHAGOPLASTY.—In twenty-four (9.9 per cent.) of the cases the œsophagus was formed in whole or in part by means of a tube from the stomach (Fig. 1). In the majority of instances (70.8 per cent.), the tube was obtained from the greater curvature of the stomach and placed in an antiperistaltic manner anterior to the thorax with its attachment in the region of the cardia according to the technic of Beck-Jianu-Halpern. Of the twenty-four, six (25 per cent.) were performed according to the technic of Hirsch; *i.e.*, the gastric tube was formed from a flap of the anterior wall of the stomach and in one (4.1 per cent.), the tube from the greater curvature was formed in such a way that it was attached to the stomach at the pylorus and functioned isoperistaltically. There were eleven males, eight females, and five in which the sex was not stated. The etiology in the group was as follows: lye, seven cases; carcinoma, six cases; benign stricture, cause not stated, eight cases; ammonia and hydrochloric acid, each, one case, and one case in which the etiology was not stated. In twelve cases in which the ages were given the oldest was sixty-eight, the youngest four, the average thirty-one years. Of the six patients with lye stricture in which the ages were given, the oldest was thirty-one, the youngest four, the average nineteen. In the four patients with cancer in which the ages were given, the oldest was sixty-eight, the youngest forty-six, the average fifty-six. The greatest number of operations in any case was eight, the least one, the average two. In the eleven instances in which the duration of symptoms before operation was stated the longest was ten years, the shortest six weeks, the average 2.7 years. In the twenty-four cases, no statement was made concerning the recovery of the patient in six. Of the remaining eighteen, thirteen (72.2 per cent.) recovered, and five (27.7 per cent.) died. Of the twenty-four, in

only two (8.3 per cent.) was the operation completed, whereas in twenty-one (91.6 per cent.) it was not completed. In only twenty was the statement made whether the operation was completed. It was completed in two (10 per cent.) and not completed in eighteen (90 per cent.). In none of the six cases in which a tube was constructed from a flap of the anterior surface of the stomach (Hirsch) was the operation completed. Similarly the formation of the gastric tube from the greater curvature with the gastric attachment at the pylorus in the case reported by Grigorjev[38] was never completed. The function was stated to be good in two (8.3 per cent.) of those started and 100 per cent. of those completed. The complications were as follows: fistulæ, four; necrosis of the gastric tube, four; regurgitation of the gastric contents, four; necrosis of the skin tube, three; necrosis of the œsophagus, stenosis, peritonitis, pneumonia, each, two; mediastinitis and infection, each, one. The extremely low percentage of cases in which the operation was carried to completion was appalling. There is indeed a great discrepancy between the percentage of those cases which recovered (72.2 per cent.) and those in which the operation was completed (10 per cent.). These figures indicate that the lack of completion was due not to the death of the individual, but rather due to technical difficulties or refusal of the patient to continue with the therapy. The high incidence of regurgitation of gastric contents (16.6 per cent.) was probably due to the fact that peristalsis through the tube was away from the stomach in seventeen of the twenty-four cases, which would tend to carry the gastric contents on to the thoracic wall. In several cases this regurgitation of gastric contents was responsible for the digestion of the skin surrounding the tube. The danger of skin digestion resulting from the contact with the gastric secretions in the gastric tube is the same as in those cases in which a skin tube is anastomosed directly to the stomach. Jianu hoped to be able to secure a sufficiently long tube from the stomach to reach to the cervical region in order that a direct anastomosis between the gastric tube and œsophagus could be made, without an intervening skin tube. This was accomplished in only one case reported by Lotheissen.[39, 40, 41] The gastro-œsophageal anastomosis failed to hold, however, resulting in a fistula which required subsequent excision of scar. The case was never completed; the defect was bridged by means of a rubber tube.

GASTRO-ŒSOPHAGOPLASTY.—In twenty-two (9.1 per cent.) cases the entire stomach was mobilized and used for the formation of the anterothoracic œsophagus. In six cases the operation was performed according to the technic of Fink; *i.e.*, the duodenum was divided at the junction of the horizontal and vertical portions, the distal end of the duodenum closed blindly, the stomach freed of its attachments except at the cardia, a posterior gastroenterostomy done, and the duodenal end brought up to the cervical region in an antiperistaltic manner deep to the skin of the thorax. In sixteen the stomach was placed anterior to the thorax isoperistaltically according to the technic of Kirschner; *i.e.*, the stomach was divided just below the cardia, the lower end of the œsophagus anastomosed with a loop of jejunum, the stomach mobilized

and placed subcutaneously anterior to the thorax up to the cervical region. In one patient reported by Kümmell,[42] in 1921, the lower end of the œsophagus was not anastomosed to the jejunal loop as suggested by Kirschner, but was closed blindly. Kümmell thought this to be permissible because of a complete inpermeable stricture in the œsophagus. A leakage of the œsophageal suture line resulted in a fatal peritonitis. In the twenty-two cases in which a gastro-œsophagoplasty was done there were eight males and five females, and nine in which the sex was not stated. The etiology of the stenosis was as follows: lye stricture, five; carcinoma, six; benign stricture, cause not stated, cardiospasm, and congenital stricture, each, one case. In five instances the cause of the obstruction was not stated. In thirteen cases in which the age was stated, the oldest was sixty, the youngest was eleven, the average 38.7 years. Of the five patients with lye stricture, the oldest was fifty-five, the youngest eleven, the average thirty-seven. Of the six patients with carcinoma, the oldest was sixty, the youngest forty-six, the average 50.5. The greatest number of operations required in any one case was six, the least one, the average 1.6. Ritter and Roith were able to complete the gastro-œsophagoplasty according to the technic of Kirschner in one stage. In both instances, however, the patient died shortly after the operation. Roith prefers a colo-œsophagoplasty to a gastro-œsophagoplasty because the latter procedure must be done in one stage, whereas the former can be done in several stages. Henschen,[43] in his second case, performed an anterothoracic gastro-œsophagoplasty, apparently in one stage, although the details are not given. The œsophagus functioned well, but the patient died six weeks later of a miliary tuberculosis. In the cases in which the duration of symptoms before operation was stated, the longest was thirty-two years in a patient with a congenital stricture, the shortest two months, the average 3.95 years. Results were given as regards the recovery following the operation in twenty-one of the twenty-two cases. Seven (33.3 per cent.) recovered, whereas fourteen (66.6 per cent.) died. Of the twenty-two cases, ten (45.4 per cent.) were completed and twelve (54.5 per cent.) were not completed. The end-result as regards function was stated to be good in six, 28.5 per cent. of those in which the operation was attempted and 60 per cent. of those in which the operation was completed. The mortality rate in the isoperistaltic gastro-œsophagoplastic group (Kirschner) was the same (66 per cent.) as in the antiperistaltic gastro-œsophagoplastic group (Fink). The operation was completed in 50 per cent. of the latter group, whereas in the former it was completed in only 43.7 per cent. of the cases. Of the cases in which the type of operation was stated the function was good in 3.3 per cent. of those done by the Fink technic and in 25 per cent. of those done by the Kirschner technic. It is only fair to state that of the ten fatal cases operated upon by the Kirschner technic, in five the obstruction was carcinoma which undoubtedly had a great deal to do with the high mortality rate.

In addition to the above types of operation described in the literature there were eight cases of anterothoracic œsophagoplasty (3.3 per cent. of the entire

series) reported in which the type of operation was not stated. The details in this group of cases are very meager. In one of the cases the obstruction was stated to follow lye ingestion. In another, the cauterizing agent was sulphuric acid. In the remaining instances the etiological agent was not mentioned. The results as regards recovery were stated in six and not in two. Of the six, four (66.6 per cent.) recovered, whereas two (33.3 per cent.) died. In six the statement was made whether the operation was completed. In two (33.3 per cent.) the operation was completed, whereas in four (66.6 per cent.) the operation was incomplete at the time of the report. The function was stated to be good in only two of the cases; whereas in the others no statement was made concerning the outcome.

Formation of a Skin Tube.—Of the various plastic operations in which a segment of colon, a tube from the stomach or the entire stomach were used in the reconstruction of the œsophagus, in only fourteen instances in which sufficient data were given was a skin tube unnecessary to complete the œsophagus. In 124 instances, however, it was definitely stated that a skin tube was used either alone or as an adjunct in the formation of the antero-thoracic œsophagus. In thirty-seven cases in which formation of a skin tube was contemplated, the tube could not be used because the operation was not completed. Undoubtedly, in many more, skin tubes were also employed but data were not given. Also in a very large number of instances the anastomosis between the mobilized intestinal segment and œsophagus and also between the skin tube and intestinal segment were accomplished by means of skin flaps. The largest single group of patients in which only a skin tube was used was that reported by Braizew.[44] This author, in 1929, reported seven cases with completed dermato-œsophagoplasties operated upon between 1925 and 1927. One case with an obstruction at the gastrocutaneous junction subsequently died of otitis media. In another there was some stenosis at the dermato-œsophageal junction. In the remaining five cases the result was excellent.

The tube in the majority of instances is formed from full thickness skin by making parallel incisions of the desired length and mobilizing the skin flaps on either side, preferably eccentrically as was done in our case in order that the suture line does not lie immediately below the suture line in the skin covering the tube. A sufficiently wide base is left attached to insure adequate blood supply to the flaps. By mobilizing the edges and approximating the skin edges an epithelial lined tube is produced (Fig. 3). Esser, on the other hand, advocated the production of a skin tube by tunneling under the skin of the anterior thorax and placing in the tunnel so constructed, Thiersch inlay grafts over a mold. He reported two cases so treated, only one of which was apparently completed. Kirschner in his first case attempted to bridge the defect between the œsophageal and the gastric fistulæ by means of a skin tube constructed according to the technic of Esser. This was unsuccessful, however, due to the suppuration of the wound. He emphasizes the importance of waiting a period of time and employing measures to

"toughen" the Thiersch graft tunnel before anastomosing the œsophagus and the stomach to it. In order to prevent a regurgitation of the gastric contents which might destroy the less resistant Thiersch grafts, he constructed a valve-like mechanism which consisted of a sac made of a pedicle flap, which became filled during regurgitation and would compress the lower end of the tube. The majority of authors are agreed at the present time that a Thiersch grafted tube is not sufficiently viable for use in an œsophagoplastic operation. As a matter of fact, the consensus of opinion is that the anastomosis of an even full thickness skin tube directly with the stomach is not desirable because of the digestion of the skin tube by regurgitated gastric contents.

FIG. 3.—Drawing showing formation of cutaneous tube by means of parallel incisions through the skin of the anterior thorax. The skin flaps so mobilized are sutured in such a way that the cutaneous surface lines the tube on the inside. At the lower portion of the drawing, the upper end of the jejunal loop is visible.

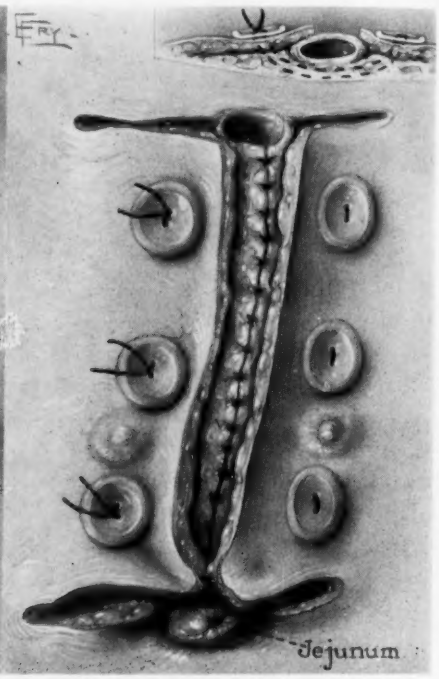


FIG. 4.—Drawing showing the covering of the skin tube by mobilization of the lateral skin edges on either side. Retention sutures are placed over buttons, the sutures passing deep to the œsophagus in order that pressure on the œsophagus is not exerted. Closure of the skin covering the newly formed skin tube. The upper end of the jejunum is visible.

In order to prevent this regurgitation of gastric contents into the newly formed œsophagus, Lotheissen advocated the formation of a valve-like mechanism at the lower end of the jejunal tube. Braizew attempted to secure the same result by means of a sling-like valve mechanism constructed from the fibres of the rectus muscle around a conus of the stomach brought out of the abdomen.

The construction of the skin tube offers little or no difficulty, and it is probably of little advantage to form it over a rubber tube as has been sug-

gested. It is imperative, however, as shown by many cases that if a rubber tube is used as a mold over which the skin tube is constructed the tube should not be left *in situ* post-operatively, because of the danger of producing necrosis at the suture line (Stieda,[45, 46] Fromme[47]). Following construction of the skin tube, the tube and the area from which the flaps are obtained must be covered in some way. Preferably this is done by mobilizing the skin of the thorax on either side well toward the anterior axillary line (Fig. 4). In some instances this mobilization may be accomplished without any difficulty and without the use of relaxing incisions. In the majority of instances, however, it is necessary to make liberal relaxing incisions on one or both sides. The error was made in our case that at the time of the production of the skin tube, the relaxing incisions were not sufficiently large to produce enough relaxation. As a result the tension was so great that the overlying skin and the upper portion of the tube gave way. There must be no tension on the suture line which may be relieved by means of retention sutures, preferably employing buttons on either side to distribute the pressure over the wide area. These retention sutures should be passed deep to the newly formed œsophageal tube in order not to exert too much pressure on the tube itself (Fig. 4). There is no general agreement concerning the time at which the skin tube should be produced. We feel that because of the greater possibility of asepsis the skin tube should be produced before the œsophageal fistula is performed. Blauel and Lotheissen, on the other hand, believe that the first stage of the œsophagoplasty should consist of an œsophageal fistula as in this way it will give sufficient time for the correction of the dermato-œsophageal stenosis while the other stages are completed. In addition, if a patient has an œsophageal fistula, it is possible for him to eat normally by connecting the œsophageal and gastric fistulæ with a rubber tube. In this way the general condition of the patient can be markedly improved because of the better mastication of food and the utilization of the salivary secretion. That such a procedure is not absolutely necessary is demonstrated by the excellent condition of our patient obtained by proper gastric tube feeding.

The majority of investigators are agreed that a preliminary gastrostomy should always be done for two reasons: (1) because occasionally a cicatricial stricture, apparently impermeable, put at rest by the use of a gastrostomy will become permeable, and the œsophagoplastic operation be unnecessary; (2) these patients, because of their inability to secure adequate nourishment, are invariably in poor condition and unable to withstand a formidable operation. Through the gastric fistula it is possible for the patient to be fed pre-operatively and prepared for operation. Lotheissen is a staunch advocate of a preliminary gastrostomy. He states that two patients were sent to him with supposedly impermeable benign œsophageal strictures for œsophagoplasty which became permeable after a gastrostomy had been performed. Many of the patients, as in our own case, are admitted to the hospital with a gastrostomy, but if such is not the case a preliminary gastrostomy should always be done. Kirschner is of the opinion that a gastrostomy is not necessary, but

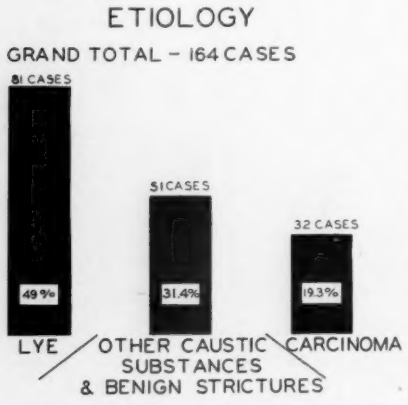
believes that patients can be fed through the gastric opening in the mobilized stomach. He feels that the presence of the gastrostomy makes the œsophagoplastic operations more difficult. Hirsch advocates that a jejunostomy should be done rather than a gastrostomy so that the anterior surface of the stomach is free for the development of a gastric tube. Lotheissen does not subscribe to this view, because he believes it is unnecessary and also because a jejunostomy does not permit retrograde bouginage. In the present series gastrostomy was done in 115 instances, was not done in twenty-three instances and in 104 it was not stated.

Mobilization of Œsophagus.—There is considerable disagreement among authors concerning the method of handling the cervical œsophagus. In the majority of instances the œsophagus has been mobilized through an incision along the anterior border of the sternocleidomastoid, as in this way it is possible to mobilize the œsophagus well into the mediastinum. Madlener,[48, 49] however, prefers the Kocher collar incision. In the present series in which it was stated, the cervical œsophagus was divided transversely in fifty-six and a lateral anastomosis was made in thirty-four. In six the œsophagus was resected for carcinoma. In twenty-three the operation was not completed to the stage of mobilization of the œsophagus and in the remaining cases it was not stated what type of operation was used on the cervical œsophagus. There are distinct advantages and disadvantages of each method. Theoretically, the ideal procedure seems to consist of the transverse division of the œsophagus and blind closure of the lower end with axial anastomosis of the upper end with either the skin tube, colon, jejunum, or stomach, as in this way the current of food is carried from the cervical œsophagus directly into the newly formed œsophagus. In case the œsophagus is not divided but an opening made in the lateral wall for anastomosis with the new œsophagus, ingested material passes into the anterothoracic œsophagus only after the blind pouch of the original œsophagus distal to the anastomosis has filled. The ingested material then spills over into the new œsophagus. Stagnation, putrefaction, ulceration, and even perforation, are apt to occur in the blind pouch. Following lateral anastomosis perforations of the blind pouch with resulting mediastinitis have been reported by Nicolaysen[50, 51, 52] and Blauel. Transverse division and blind closure of the distal portion of the œsophagus is also not without danger. Contamination of the mediastinum from the retracted distal segment may result fatally as in the case of Hauck. Denk[53] warns against the blind closure of the distal segment because of the danger of increased mucous secretion and possible perforation. Ideally, if the œsophagus can be mobilized down to the point of stricture and divided at that point and closed, little or no trouble should be encountered. Lotheissen reports a case, however, in which this was done, the lower end not being ligated. The fistula became patent and the patient developed a purulent mediastinitis. There is some danger if the lower end is closed blindly of the development of a cyst, as reported by Heyrovsky.[54, 55] This is due to the accumulation and retention of secretion in the blind segment of œsophagus.

The lower end of the œsophagus if closed blindly should be brought out either at the lower end of the cervical wound or in a wound posterior to the sternocleidomastoid muscle, as suggested by Schreiber, Esser, and Bornhaupt. In this way, if any leakage should occur, it will escape to the outside. In order to prevent accumulation of mucus in the distal portion of the transversely divided œsophagus, Heyrovsky anastomosed the lower end of the œsophagus with the side of the skin tube. Because this anastomosis became stenotic, however, a large cyst of the œsophagus developed in the mediastinum. The operation was not successful. The danger of stenosis in the axial anastomosis is much less than in the lateral anastomosis. Axhausen[56, 57, 58] and Blauel, however, believe that the tendency toward stenosis in a lateral œsophageal anastomosis can be obviated by suturing the opening in the lateral wall of the œsophagus to skin flaps in order that there is no tension between the œsophageal mucosa and the skin. They are of the opinion that the tendency toward stenosis at the dermato-œsophageal junction is due entirely to the tension on the suture line. In the present series the lower end of the œsophagus was closed blindly in thirty-seven instances, in four instances it was left open, and in 136 instances no statement was made. The lower end of the œsophagus has been closed blindly by Herzen, Exner,[59] Frangenheim, Ranzi,[60] Marwedel,[61, 62] and in our case. The advocates of the lateral anastomosis are Lexer, Frangenheim, Rehn, Stieda, and Blauel. Hirschmann[63, 64, 65] and Blauel are convinced that the anastomosis between the œsophageal fistula and the remaining portion of the œsophagus should not be made until the mucocutaneous junction at the œsophageal fistula has well healed, as only in this way can the tendency toward stenosis which has been observed so frequently be obviated.

Mobilization of the Jejunal Loop.—In the construction of the jejunal loop there is some controversy concerning the length of the loop which can be chosen and also the way in which it should be brought into the upper abdomen. Although it is ideal to have a sufficiently long loop of bowel, as first suggested by Roux, to reach from the stomach to the cervical region so that a direct anastomosis of the œsophagus and the jejunum might be accomplished, this procedure usually is not feasible because of the high incidence of gangrene in the distal portion of the jejunal loop (22.2 per cent. in the present series). At no time should a sufficiently long loop of bowel be chosen which will jeopardize the nutrition of the loop. That a long loop of jejunum can at times be successfully mobilized without danger of circulatory failure is shown by the results obtained by Jankovski,[66, 67] Axhausen, Leischner,[68] and Riesenkampff.[69] These authors successfully mobilized jejunal loops 40 centimetres, 60 centimetres, and 75 centimetres in length, respectively. Of sixty instances in which it was stated, in fifty-three the mobilized jejunal loop and its attached mesentery were brought up through the lesser sac, passing first through the transverse mesocolon and then through the gastrocolic omentum. In five instances, the technic as originally suggested by Roux; *viz.*, the bringing of the mobilized segment of gut around the trans-

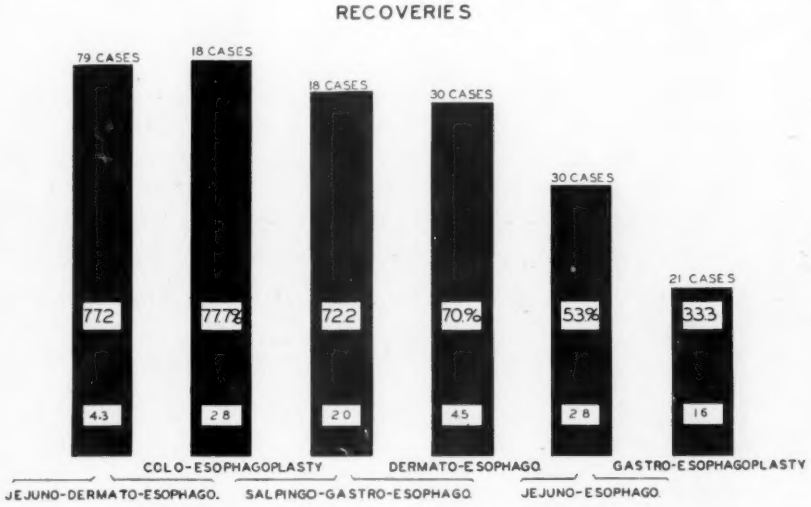
verse colon was used. That the former is to be preferred to the latter is quite obvious, because of the greatly diminished danger of interference with the blood supply to the loop of bowel by preventing the compression of the mesentery by the transverse colon. Frangenheim believes that the Roux procedure is permissible in children. As emphasized by Axhausen, Hirschmann, Blauel, and Bornhaupt, it is of importance in mobilizing the loop of bowel to secure a loop only long enough to serve as an intervening tube between the stomach and the skin tube. At no time should a sling or dependent loop be allowed to remain within the abdomen in which stagnation of food may occur. Wullstein's suggestion of not completely dividing the jejunal loop, but leaving it attached and allowing the ingested food to enter directly into the jejunum is not practiced at the present time. The technic of the Y-anastomosis; *viz.*, the bringing up of the jejunal loop through the lesser sac anterior to the stomach and the anastomosis of the oral segment into the distal portion permits a possible two-stage operation and allows the first stage to be shortened considerably. At a subsequent stage the jejunum is divided just below the stomach, the lower end closed blindly, and the upper end anastomosed either end-to-side or side-to-side with the anterior wall of the stomach. The advantage of the two-stage procedure is that each operation is less formidable. The disadvantage, however, is that the second operation; *viz.*, the division of the jejunum and the anastomosis of the upper end with the stomach is made considerably more difficult because of the dense adhesions which form between the first and second operations. Blauel believes that if the second stage is done within a relatively short period of time after the first, adhesions will offer little difficulty. He and Wiedemann[70] maintain that ideally the abdominal operation should be completed in one stage. Blauel does not agree with von Hacker that colon is to be preferred to the small bowel, because the former has less tendency to develop adhesions than the latter. In order to prevent pressure on the mobilized segment of bowel as it passes through the abdominal wall, Axhausen and Denk suggest removing an elliptical portion of the fascia on either side. Whereas the majority of authors are agreed that the jejunal loop can be brought up anterior to the thorax in a tunnel formed under the skin, Slawinski,[71] Grekow,[72] and Wiedemann are of the opinion that this should not be done, but rather that an incision with mobilization of flaps on either side should be accomplished. Slawinski concludes this because the dragging of the jejunum through a skin tunnel resulted in necrosis of the jejunal loop in one of his cases. Syring[73] warns against the placing of a jejunal loop antiperistaltically



GRAPH II.—Graph showing etiological factors in the production of œsophageal stricture and stenosis.

as he did in one case. There was continued regurgitation of gastric contents through the loop which subsequently required multiple operations. Excision of the loop was advised. The patient refused and died. He does not agree with Frangenheim that it makes little difference whether the loop is placed isoperistaltically or antiperistaltically, or with Kümmell that a loop of bowel placed anterior to the thorax loses its normal peristaltic activity. He feels also that the reconstruction of the gastric tube from the greater curvature, according to the Beck-Jianu-Halpern method and the placing of the entire stomach anterior to the thorax according to the Fink method is not justified, because of the possibility of reversed peristalsis and the emptying of gastric contents to the outside.

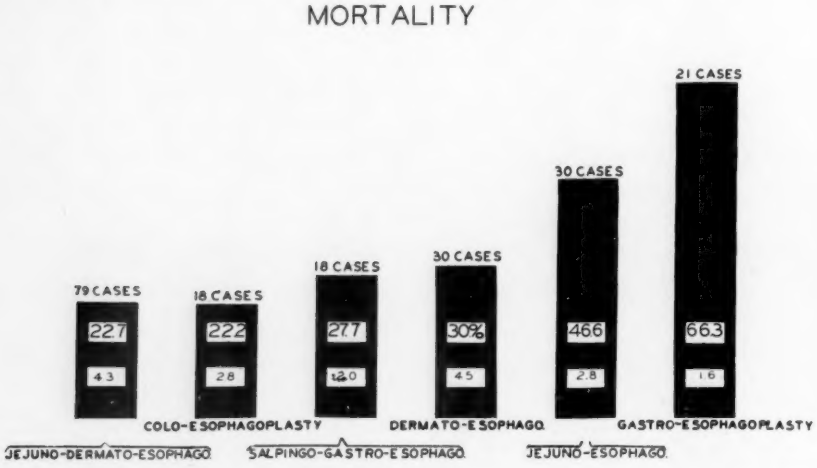
In the 240 cases included in the present series the cause of the obstruction was stated in only 164 (Graph II). In eighty-one of these (49 per cent.)



GRAPH III.—Graph representing the recoveries resulting from the various types of operative procedures in performing an anterothoracic œsophagoplasty.

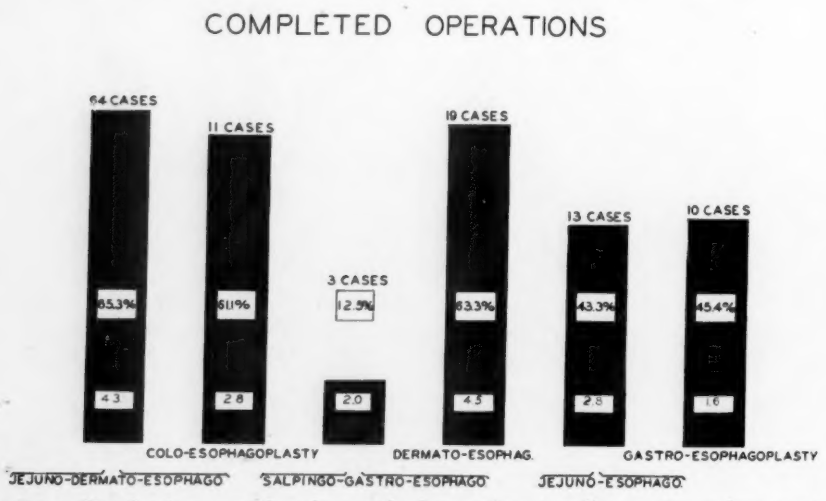
lye was stated as being the caustic substance ingested which was responsible for the obstruction. Other caustic substances and benign strictures were responsible in fifty-one cases, or 31.4 per cent. These fifty-one cases were divided as follows: benign stricture, the cause not stated, twenty-four cases; congenital, two cases; cardiospasm, one case; sulphuric acid, four cases; acetic acid, two cases; ammonia, three cases; hydrochloric acid, ten cases; chloric acid, silver nitrate, potassium permanganate, œsophageal fistula following empyema, and formalin, each, one case. There were thirty-two (19.3 per cent.) cases in which the cause of obstruction was carcinoma. This high percentage of œsophagoplasties performed for a malignant lesion indeed does not speak well for the surgical indications in the particular cases. We agree heartily with Blauel and Bornhaupt that an œsophagoplasty should be done in those cases of carcinoma only when the malignant lesion has been completely extirpated. The operation, an anterothoracic œsophagoplasty with

its numerous procedures, is not justified in a patient with carcinoma who can be made comfortable the remaining days of his life by gastrostomy feeding. We also agree with Lotheissen and others that the œsophagoplasty is not



GRAPH IV.—Graph representing the mortality percentages resulting from the various types of operative procedures done in performing an anterothoracic œsophagoplasty.

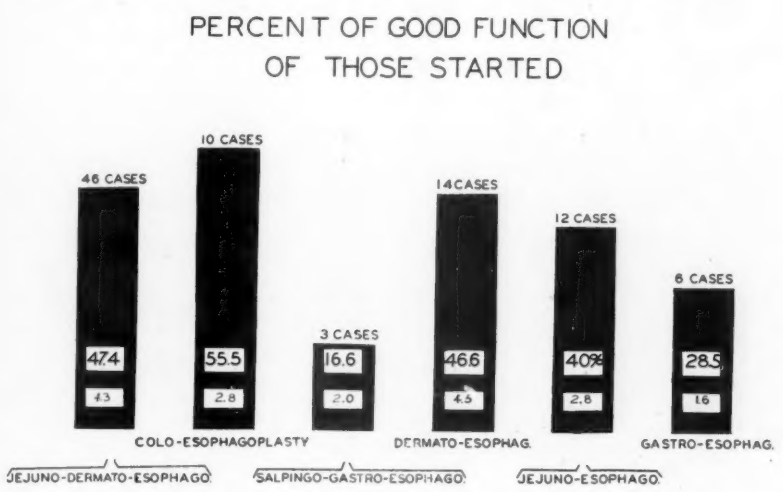
justified in cases of benign stricture unless the stricture is impermeable and feel that with few, if any, exceptions the proper treatment of the original cauterization of the œsophagus by early and persistent bouginage will pre-



GRAPH V.—Graph representing the completed operations according to the various types performed.

vent an impermeable stricture from developing. Lotheissen recommends a chemical test which consists of letting the patient drink 15 to 20 cubic centimetres of a 2 to 5 per cent. solution of ferric lactate. The gastric contents are then aspirated from the gastrostomy opening and determination of the presence of iron in the stomach is made.

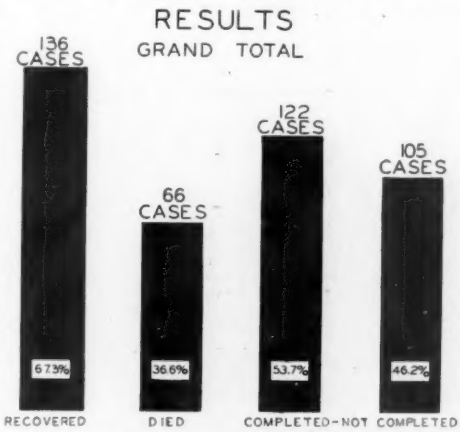
As mentioned above, occasionally an apparently impermeable stricture will open up after putting the œsophagus at rest by the production of a gastrostomy. This is due to the fact that the inflammatory œdema subsides. Sauerbruch[74] reports a case in which he started an œsophagoplasty, but which was not completed because the thoracic œsophagus again became patent. In a



GRAPH VI.—Graphic representation of percentage of good function resulting from the various operative procedures performed in those cases started.

case operated upon by von Hacker,[75, 76, 77, 78, 79, 80, 81] the thoracic œsophagus also became patent and the patient subsequently swallowed through both œsophagi. Such, obviously, should never be allowed to occur.

In seventy-one patients with stricture following lye cauterization in which the age was given the oldest patient was fifty-five years, the youngest three, the average 20.9 years. Of sixteen patients with a malignant obstruction in which the age was given, the oldest was sixty-eight, the youngest forty-one, the average 51.5 years. Of the 240 cases there were 152 in which the sex was stated, of which there were seventy-six males and seventy-six females. In eighty-eight the sex was not stated. Of the 242 operations which were done, in fifteen no statement was made whether the operation was completed. In the remaining 227, these data were given. In 122 (53.7 per cent.) the operation was completed, whereas in 105 (46.2 per cent.) the operation was incomplete at the time of the report (Graph VII). Of the 240 cases, in thirty-eight instances



GRAPH VII.—Graphic representation of results following operative procedures for œsophageal strictures.

no mention was made as to whether the patient recovered. In the remaining 202 cases, 136 (67.3 per cent.) recovered and sixty-six (32.6) died. Of the entire 242 operations performed in the series in only ninety-five was the result stated. In ninety-three of these the result was considered to be good; in two it was considered to be poor.

The mortality rate of 32.6 per cent. in this collected series is high. When one realizes that this is based upon the cases done during the stage of development of œsophagoplastic procedures and that a number of operations are frequently necessary to complete an anterothoracic œsophagoplasty, the figure is not as prohibitive as it would seem at first. The highest mortality rates occurred in those groups in which either the entire stomach or a long loop of small bowel was used in the reconstruction of the œsophagus, being 66.3 per cent. and 46.6 per cent., respectively. The lowest mortality rates occurred in those series in which the colon was used or a combination of small bowel and skin tube, being 22.2 per cent. and 22.7 per cent., respectively. The highest percentage of completed operation was in the jejuno-dermato-œsophagoplastic group. Next in frequency was the dermato-œsophagoplastic group in which only skin was used to construct the new œsophagus, the percentages being 65.3 and 63.3, respectively. The lowest percentage of completed operations was in that group in which a tube was formed from the stomach, it being 8.3 per cent. Of all the cases in which the operation was started and in which the end-result was stated, the highest incidence of good function was obtained in the colo-œsophagoplastic group (55.5 per cent.), followed in frequency by the jejuno-dermato-œsophagoplastic group (47.4 per cent.).

The following case of anterothoracic œsophagoplasty is reported:

Case Report.—Patient, aged four, white female, admitted to Charity Hospital, July 12, 1927. C.C.—Vomiting and inability to retain food. P.I.—About three months ago patient drank some lye water. She was taken immediately to a doctor, who performed a gastric lavage, only twenty minutes elapsing between time of ingestion until she was seen by physician. Patient apparently was making satisfactory progress until seven weeks later, when she developed measles. During the period between the time she ingested the lye and the onset of measles she had lost little weight, during the measles, however, she lost considerable. Shortly after this she began to vomit and was able to retain no food. The vomiting grew progressively worse, but was associated with no fever. There has been a chronic cough since the onset of the measles. P.H.—The general health of the patient had been good. She has had whooping cough and measles. No history of any other serious illness. F.H.—Father living and well. The mother is living and has leprosy. A twin sister in good health. P.E.—Patient is a small, fairly well developed, but poorly nourished white child. Definitely underweight and showing signs of extreme emaciation. Weight, 20 pounds.

On July 1, 1928, otolaryngological consultation disclosed the œsophagus gradually closing, the stricture almost complete, and only a small amount of liquids being retained. General condition fair. Patient unable to swallow string because of lack of coöperation. Aug. 1.—A small bougie passed following which several cups of water were swallowed and retained. The patient responded well to this dilatation, and showed signs of marked improvement, but developed a bronchopneumonia from which she recovered. On November 3, a second dilatation was done, without reaction. Weight, 30 pounds.

Jan. 22, 1929.—Readmitted. Has lost considerable weight. Now 23 pounds, 4 ounces. Examination of chest reveals a chronic bronchitis with a slightly productive cough, temperature 99°. She continued to improve and gain weight and on Nov. 5, a third œsophageal dilatation was done, since which she has been making satisfactory progress, being fed entirely through a gastrostomy tube. Discharged, Nov. 21, 1929. Readmitted Feb. 17, 1930, for an œsophageal dilatation, which was repeated on Sept. 1.

Sept. 6, 1931.—Readmitted. Weight, 37 pounds. Patient unable at this time to drink any fluids whatever, is taking all nourishment through gastrostomy tube. On Sept. 12 an unsuccessful attempt made to pass a sound through the œsophagus. A second attempt to pass a sound with the aid of the endoscope also unsuccessful, as was an attempt at retrograde bouginage, which was again unsuccessful on Nov. 22, and the patient was discharged as being impossible of dilatation. Patient in a debilitated condition, with progressive expectoration. Weight 37 pounds 4 ounces. June 18, 1933.—Readmitted to Charity Hospital, on Surgical Service. Her condition is good, although complexion is

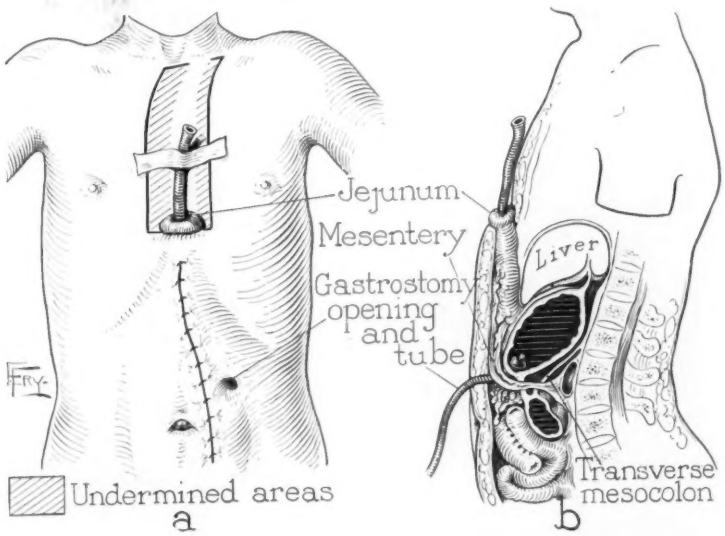


FIG. 5.—Diagrammatic drawing showing the incision used in the formation of the skin tube from the skin of the anterior thorax. As is seen in the figure on the left, the flap on the right side is undermined for a greater distance than on the left. In this way the suture line does not lie directly above. On the right, the production of the jejunal tube, the mesentery of which is brought up through the lesser sac. Jejunal tube is anastomosed with the stomach, and its position beneath the skin of the lower portion of the thorax is demonstrated.

sallow. Has gained steadily in weight, but still unable to take anything through the œsophagus.

First Stage of Œsophagoplasty Performed.—June 27, 1933.—Under ether anæsthesia a left rectus incision was made, abdomen explored and jejunum isolated. The jejunal loop 12 inches distal to the ligament of Treitz divided. Both ends of the jejunum closed blindly by purse-string sutures. The mesentery of the jejunum distal to the division divided close to its root for a distance of about 6 centimetres, the vessels being severed only after it was seen that compression did not produce any change in the color of the loop of bowel. An opening was made in the avascular area of the transverse mesocolon and the proximal end of the distal portion of the divided intestine brought through the transverse mesocolon into the lesser sac and through the gastrocolic omentum. The distal end of the proximal loop of divided intestine was then anastomosed to the jejunum by a side-to-side anastomosis, approximately 10 inches distal to the proximally divided end. The jejunum proximal to the jejunostomy was next divided and the distal end turned in as in the

previous procedure, and the proximal end anastomosed to the anterior wall of the stomach by an end-to-side anastomosis in the region of the lesser curvature about its midportion. The upper end of the free jejunal loop was brought through the end of the abdominal incision and placed in a subcutaneous tunnel extending for a distance of about 5 centimetres upward. The upper end of the loop emerging through a transverse incision at the upper end of the skin tunnel, was sutured to the skin (Fig. 5b).

July 2.—Sudden rise and persistent septic type of temperature. Patient received glucose and saline infusions and several transfusions of whole blood. On July 6, while

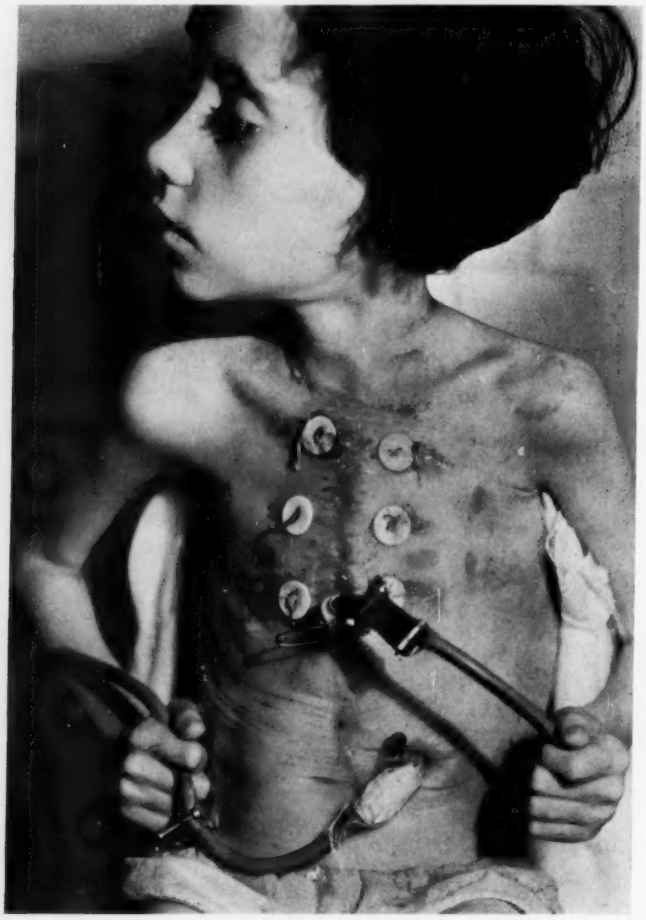


FIG. 6.—Photograph of patient, September 25, 1933, following the second stage œsophagoplasty. The lower tube is a gastrostomy tube. The upper tube is inserted in the jejunum. The buttons used as retention sutures are plainly visible.

attempting to administer milk through a catheter supposed to be inserted into a loop of jejunum, the catheter was forced along the line of cleavage just outside the jejunal loop downward into the peritoneal cavity. About one quart of milk was introduced through this tube and into the peritoneal cavity instead of being poured into the stomach as was intended. Following this the patient went into extreme shock, pulse 160, respiration 26, temperature 98.6°. At 2:00 P.M. the pulse was 140, temperature 99, respiration 22. The pulse remained elevated for the next four days, ranging between 140 and 100, and the temperature between 99 and 102. On July 18, patient shows signs of toxicity, with evi-

dence of an abdominal wall abscess. This was incised and drained. A thin, sour-smelling pus was evacuated. A small cavity was found between the fascia and the abdominal wall, and the same material seen to be coming from the depth of the wound, which, after exploration and dilatation, was found to extend into a large intraperitoneal abscess extending down midway between the symphysis and umbilicus, from which approximately 100 to 150 cubic centimetres of fluid, apparently containing milk, was evacuated. The cavity was temporarily packed with thin gauze.

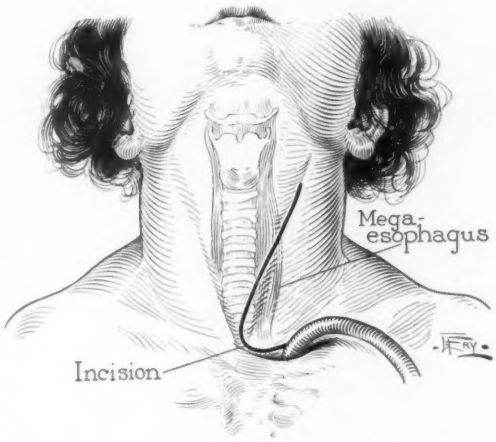


FIG. 7.—Drawing showing the upper end of the completed skin tube at the sternoclavicular junction and the incision used in the third stage œsophagoplasty to expose the œsophagus. The incision is curved at its lower end in order to produce a flap, which is used to cover over the œsophageal cutaneous anastomosis. The dilated œsophagus is shown in the background.

Second Stage Œsophagoplasty.—Sept. 12.—Two parallel incisions about 2½ inches apart, extending from the jejunal loop up to the left sternoclavicular articulation, were made so that they were somewhat to the left of the mid-line. Skin flaps undermined, the right for a distance of approximately one inch and the left for a distance of only ½ inch. Transverse incisions were made through the skin at the upper and lower limits of the parallel incision above described (Fig. 5b). The tube was then constructed by means of interrupted sutures of 0 catgut, being placed in the dermis but not passing through the epidermis (Fig. 3). A second row of interrupted 0 catgut was placed in the subcutaneous tissue, thus completing the tube. The tube so constructed was covered by undermining the lateral skin flap from either side and approximating them by means of interrupted tension sutures of silkworm gut, being placed so that they were situated underneath the newly formed skin tube. The tension sutures were drawn through buttons (Fig. 4). After tightening the tension sutures and with the aid of lateral relaxation incisions, it was possible to approximate the skin edges over the tube by means of interrupted paraffinized silk sutures, which were placed without tension. The patient made an uneventful recovery and was up in a wheel chair Sept. 17 (Fig. 6).

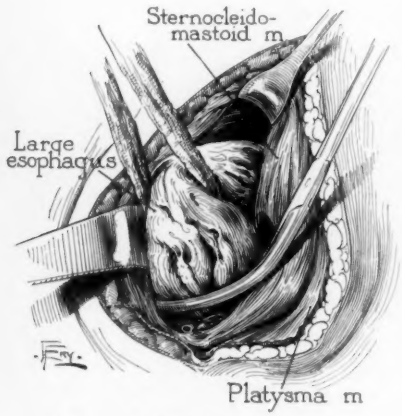


FIG. 8.—Mobilization of the œsophagus. A tape has been placed around the hugely dilated œsophagus after the œsophagus has been carefully separated from the surrounding structures. This mobilization has extended down well into the mediastinum. A right angle clamp is being placed on the œsophagus in its lower portion. Similarly another clamp will be placed above this.

Third Stage Œsophagoplasty.—Nov. 14.—The upper end of the skin tube, which had separated following the last operation was closed. The reformed tube was made by suturing the edges which go into the formation of the lining of the tube with 000 catgut, the sutures being tied inside. The skin previously had been relaxed by two lateral incisions running obliquely outward from a point just below the clavicle toward the anterior axillary line. These were about 7 centimetres in length. The skin between the relaxation incisions and the skin tube was thoroughly undermined. Following this procedure it was possible to approximate the edges of the skin which

went into the formation of the roof of the skin tube with little difficulty. The anterior covering of the skin tube, which was formed by attaching the two skin borders of the skin immediately overlying the inner lining of the skin tube, was sutured with end-on mattress sutures of 0000 silkworm gut. The denuded areas caused by separation of the skin edges at the point of relaxation incision were grafted by Thiersch grafts taken from the right thigh. An impression of these areas was first taken with a stent made of dental compound. The Thiersch grafts were placed over the stent and inserted into the wound where they were held in place by pressure applied to an overlying sea sponge, fluffy gauze, and a bandage. Patient recovered from this procedure very rapidly and with no difficulty.

Fourth Stage Œsophagoplasty.—Jan. 1, 1934.—Curved linear incision made beginning in the region of the hyoid bone and following along the anterior border of the

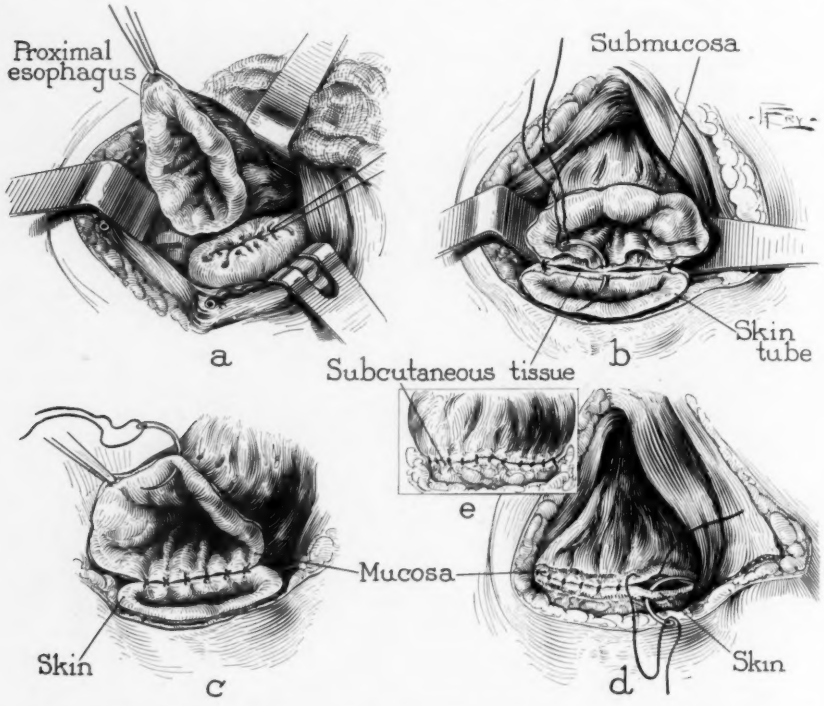


FIG. 9.—Drawing showing the method of treating both ends of the œsophagus. (a) The distal end has been closed by means of a purse-string, and following this is allowed to sink into the mediastinum. The upper end is seen to be markedly dilated. (b) Anastomosis of the upper dilated end to the œsophagus with the skin tube. Because of the disproportion in the two ends, some difficulty was encountered in accomplishing this. By using the interrupted sutures, however, it was accomplished as shown in (c), (d), and (e). As shown in (b) the first line sutures passed through the submucosa and the subcutaneous tissue, whereas the second line of sutures passed through the epidermis and the mucosa.

sternocleidomastoid muscle, extending obliquely downward and medially to approximately 1 centimetre above the clavicle where the incision was then turned laterally beyond the opening of the previously opened skin tube, being about 1 centimetre above this level (Fig. 7). The anterior jugular vein was ligated; the sternomastoid muscle retracted laterally, thus exposing the deep cervical fascia overlying the carotid sheath. This fascia was incised longitudinally, exposing the carotid sheath which was retracted laterally. The trachea and left recurrent laryngeal nerve were retracted medially, care being taken not to injure the left inferior thyroid artery in order to conserve as much of the blood supply to the œsophagus as possible. The œsophagus was isolated by sharp and blunt dissection and it was found to be enormously dilated just above the point of stricture,

being approximately 4 centimetres in diameter. In separating the œsophagus anteriorly it was found that numerous dense adhesions were present around its entire circumference and in attempting to free some of these an opening was inadvertently made in it. There was an immediate escape of stagnant œsophageal material which contained nuts and food particles. The opening was grasped with forceps and sutured with 00 catgut. The wound quickly aspirated and the head of the patient lowered to an extreme degree in order to effect as much drainage as possible toward the mouth. In freeing more of the dense fibrous adhesions encircling the œsophagus another perforation was made. It seemed impossible to find any line of cleavage whatsoever and in freeing one of the very dense adhesions on the anterior surface of the œsophagus, the trachea was opened in its posterior aspect. This was sutured with interrupted 00 catgut. The œsophagus was mobilized well into the superior mediastinum. An umbilical tape was used to bring the freed mega-œsophagus into the wound (Fig. 8).

About 8 centimetres below the level of the suprasternal notch, within the thorax, two crushing right angle kidney pedicle clamps were applied to the œsophagus, and it was divided between these clamps. Over the lower clamp a continuous suture of No. 1

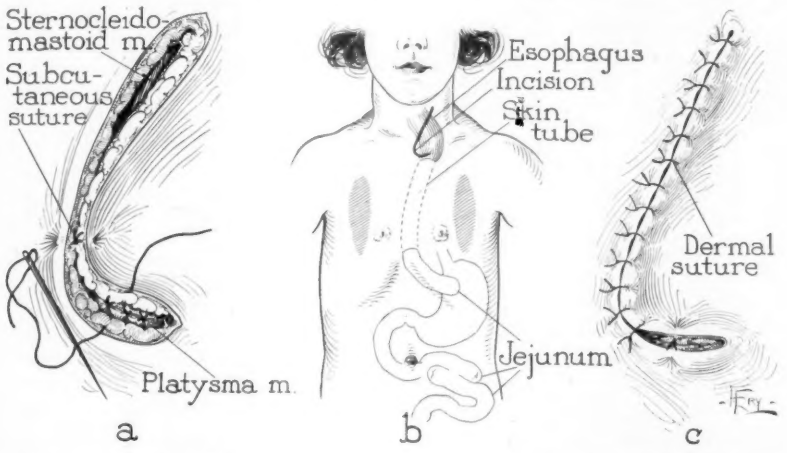


FIG. 10.—Showing the closure of the cervical wound after the œsophageal-cutaneous anastomosis. The flap produced by the incision permits the covering of the anastomosis very satisfactorily. (b) Diagrammatically shows the reconstruction of the new œsophagus, the upper portion of the œsophagus, the mid-portion of skin, and the lower portion of the jejunum.

chromic catgut was placed. The ligated stump inverted by means of a purse-string suture (Fig. 9a). The distal end of the proximal portion of the œsophagus anastomosed to the upper end of the skin tube. The anastomosis was accomplished by placing a row of submucosal and subcutaneous sutures posterior in such manner that the ends of the two tubes were approximated (Fig. 9b). Following this, the mucosa and the skin posteriorly were sutured by interrupted silk in the same manner (Fig. 9c). Anteriorly the mucosa and the skin sutures were applied in such a manner that the knot was tied within the lumen. Over this the submucosal and the subcutaneous tissues were sutured by means of interrupted silk. Because of the great disproportion in size of these two tubes this was accomplished with some difficulty, but apparently satisfactorily. A rubber dam drain was placed in the posterior mediastinum behind the inverted œsophageal stump and brought out through the upper end of the wound. The flap was again replaced in position over the œsophagus and subcutaneous sutures of 00 plain catgut were taken. Following this the skin was sutured with interrupted silk (Fig. 10a and c).

On Jan. 2.—Patient shows some toxicity. Wound red; a serous discharge which was foul-smelling, typical of a spirochetal infection; Vincent's organisms were demonstrated; 0.075 Gm. of neoarsphenamine given intravenously. On Jan. 12, temperature 100. The

secretions very quickly lost the foul-smelling odor which was first noticed and the wound looks better. Wound entirely healed with the exception of a small fistulous opening, and no infection present on Jan. 16. By Mar. 10, patient's progress satisfactory. Had gained in weight up to 51 pounds, and was up and about the ward; she was taking viosterol and liver daily.

Fifth Stage Œsophagoplasty.—Apr. 17.—Excision of scar tissue from the skin over the junction of the œsophagus and skin tube down to the connection of the œsophagus with the skin tube. A circular incision was made completely around the œsophagus above, cutting through the dense scar tissue in its entirety. This incision freed the œsophagus from its scar tissue attachment, thus mobilizing it to a fair degree. The same procedure was used in mobilizing the proximal end of the skin tube below. Following this the œsophagus and the skin tube could be brought into approximation with little difficulty and with not too much tension. A layer of interupted 00 chromic sutures was taken, passing through the submucosa of the œsophagus and through the subcutaneous layer of the skin tube in such manner that the œsophagus and skin tube were approximated without causing too much tension on the suture line.

The mucosa of the œsophagus and the epidermis of the skin tube were sutured. These sutures were made with considerable difficulty because the circumference of the œsophagus was considerably larger than that of the skin tube and consequently there was a marked redundance of the œsophagus. This condition made the correct approximation of the œsophagus with the epidermis of the skin tube quite tedious. There was considerable dead space lying beneath the œsophagus after completion of the anastomosis, so that two small pieces of rubber dam were placed one on either side of the œsophagus and brought out through the angle of the wound. The skin wound was closed with interrupted sutures of 0000 silkworm gut. Patient reacted from this operative procedure quite satisfactorily. 0.075 Gm. of neosalvarsan given intravenously.

April 18.—Wound red and œdematous. Hot, moist applications started. Wound treated with application of 5 per cent. neoarsphenamine in glycerine and also applications of gentian violet. Patient permitted to swallow three times daily one ounce of 1:10 Fowler's solution. This latter procedure was done with impunity as the solution merely rinsed the œsophagus and skin tube, emptying itself outside the body into the dressings at the lower end of the skin tube. The wound responded nicely and there was never at any time the suggestion of the foul-smelling odor typical of spirochetal infection which had been present following the original anastomosis of the œsophagus with the skin tube. On May 10 a catheter was inserted up through the skin tube past the junction of the œsophagus and the skin tube. This catheter conducted all secretions from the mouth, and no leakage was observed at the small fistulous opening in the neck. There was, however, almost a constant flow of saliva coming out the distal end of the catheter. Each time the patient swallowed a small amount of saliva was forced out through the lower end of the catheter. Patient made satisfactory progress and continued to improve and gain weight.

Sixth Stage Œsophagoplasty.—May 24.—A plastic closure of the space between the upper jejunal loop and the skin tube was accomplished by means of a skin pedicle flap. The skin flap was sutured to the lower anterior ¾ of the circumference of the skin tube. This particular type of flap was chosen in order to avoid having a suture line at the inferior border of the flap which would, if present, be situated in a particularly vulnerable position, as any fluid passing from the œsophagus above would come in contact with this suture line with more force than if it were situated in the upper arch of the closure. An incision was made around the anterior ¾ of the circumference of the skin tube and a small cuff of this portion of the skin tube raised and turned downward in preparing it for its attachment with the flap below. The junction of the edge of the flap beneath was sutured to this cuff of the anterior skin tube. This formed the anterior portion of the wall of the newly formed œsophagus at the point of the junction between the skin tube and the jejunal loop. The closure was made by a continuous suture of 00 chromic gut in

such a manner that the edges were slightly inverted and approximated on the inside. This was reinforced by a second row of interrupted 00 chromic catgut sutures. The closure of the skin over the roof of the anastomosis thus formed was effected by undermining the skin on either side of the defect, and this was aided by two relaxing incisions, 10 centimetres in length, which were placed about the level of the seventh rib in the anterior axillary line. Following this the skin was sufficiently freed and relaxed to approximate the newly formed roof of the œsophagus. The closure of the skin edges was done by the aid of tension sutures of silkworm gut placed through buttons. After the tension sutures of silkworm gut were placed, other interrupted sutures of fine dermal were taken. At the completion of the operation patient was in shock, but recovered following infusions and a transfusion. On the following day condition excellent. May 26, patient's condition is quite good. Temperature, pulse, and respiration normal. The wound shows some increased redness. May 29, 1934, patient's general condition is excellent. The wound still shows some redness. About one-half dram of pus expressed from the upper border of the wound. No definite fistula has apparently formed, although this may be a forerunner of one.

Discussion and Conclusions

Based on our own personal experience in the reported case and the review of the literature, we feel that the procedure of anterothoracic œsophagoplasty should be used only in cases of absolutely impermeable benign stricture of the œsophagus or in cases of carcinoma in which the tumor has been extirpated. We also feel that if cases of cauterization of the œsophagus are adequately treated from the beginning few, if any, cases will develop an impermeable stricture. It is conceivable, however, that a case with a massive necrosis of the œsophagus may develop a stenosis which cannot be satisfactorily dilated. These are indeed exceptional. In a review of the cases which have been operated upon it is evident that the best results have been obtained in two groups of cases; *viz.*, those in which the operation has been accomplished by using a segment of colon and those in which a newly formed œsophagus has been constructed out of a loop of jejunum and a skin tube. Whereas the results obtained in making a colo-œsophagoplasty are equally as good as those obtained by a jejuno-dermato-œsophagoplasty it seems to us that, in spite of the many more operations required, the latter procedure is to be preferred. As shown by many of the reports in the literature even though the colon can be used for the reconstruction of the œsophagus, stasis within the newly formed œsophagus is apt to occur with the formation of a ruminating stomach. It should be emphasized that in mobilizing a jejunal loop the attempt should never be made to secure a loop of such length that the blood supply of the bowel will be in jeopardy. Undoubtedly, this has been responsible for the high incidence of failure and fatalities in the jejuno-œsophagoplasties in which an attempt was made to form the œsophagus entirely from the jejunum. Based on our study of the literature and on the difficulties encountered in our own case, we feel that the first stage of the jejuno-dermato-œsophagoplasty should consist of the mobilization of the jejunal segment. This should be brought up through the lesser sac, completely mobilized, and the distal end anastomosed to the stomach, care being taken

not to have a dependent loop. The proximal end should be brought up through a skin tunnel anterior to the thorax. The upper end of the jejunum which is brought out through a small transverse incision is sutured to the skin edges without opening up the bowel. The second stage should consist of the formation of the skin tube and the immediate completion of the junction between the skin tube and the jejunum in a way depicted in Fig. 11. This is accomplished by extending the lateral incision for the formation of the skin tube down and around the jejunal opening. In this way a flap is produced which can be mobilized upward to be anastomosed to the skin tube,

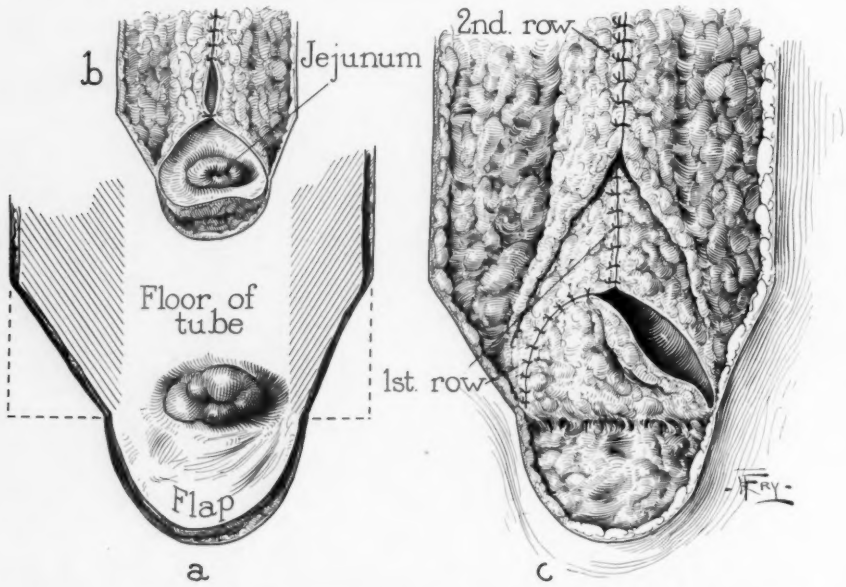


FIG. 11.—(a) Represents the skin incision used for the formation of a skin tube which includes a skin flap below the anastomosis of the jejunal loop with the skin. (b) Represents the manner in which the skin tube is formed by inverting the edges of the lateral skin flaps and approximating their borders with intradermal skin sutures. This also demonstrates the manner in which the lower flap is folded upward and approximated with the lower borders of the lateral skin flaps. When the above procedure is completed, one will see that a skin tube is formed, which completely encloses the anastomosis of the jejunum with the skin. (c) Represents the manner in which the lateral and the lower skin flaps are approximated in the formation of the skin tube. All sutures are intradermal.

covering over the opening of the jejunum. The advantage of this procedure is that the suture line is in such a position that there is relatively little tension on it, and also because the anastomosis with the jejunum is surrounded by a floor of normal skin. Following this, the newly formed skin tube, the anastomotic site, and the defects produced by the mobilization of flaps are covered by mobilizing skin flaps on either side. Relaxing incisions are necessary. Sufficient time is allowed to elapse between completion of this stage and the third stage of the œsophagoplasty for the wound to heal completely, as in this way there will be less danger of infection from the contaminated mouth secretions. As a third stage the cervical œsophagus is mobilized after making a curved incision as described in the drawings, the incision passing along the anterior border of the sternocleidomastoid to a point just above the

clavicle and then coursing laterally. The œsophagus is mobilized well into the mediastinum. The upper end of the previously formed skin tube is freshened by a transverse incision, and the skin forming the lining of the tube is separated from the skin covering it. The œsophagus is mobilized well down into the mediastinum, doubly clamped by means of right-angled clamps and divided transversely. The lower end is closed blindly by means of inverting sutures. The upper end is brought up into the wound and the distal segment of the upper end is invaginated into the upper end of the

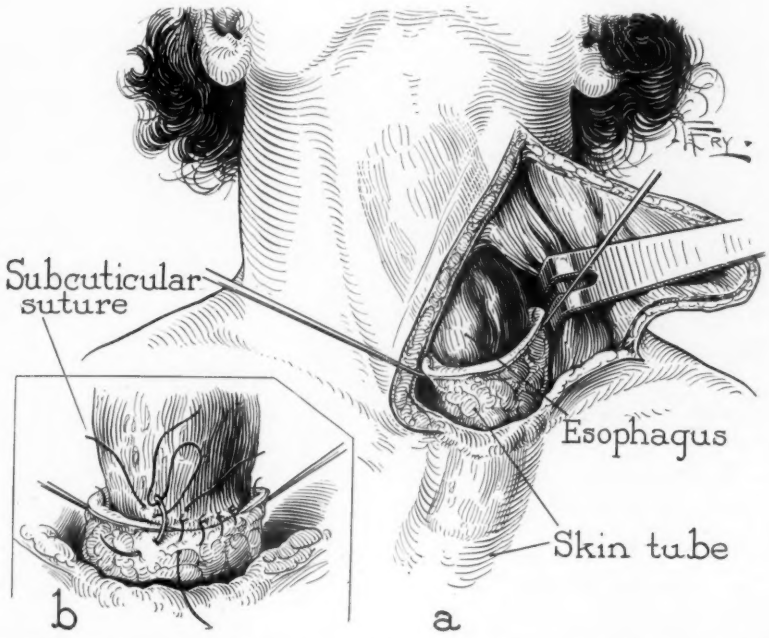


FIG. 12.—Represents the incision used for the formation of a triangular skin flap over the lateral surface of the neck through which the œsophagotomy is performed. The upper end of the previously formed skin tube is pared by a transverse incision and the skin forming the lining of the tube is separated from the skin covering the tube. The œsophagus is then sectioned at a point sufficiently low to permit one to insert the distal end of the oral segment well down into the skin tube. Salivary drainage through this portion of the œsophagus will then go directly into the stomach without contaminating the site of anastomosis between the œsophagus and the upper end of the skin tube. (b) Represents the manner in which the approximation sutures are taken through the outer portion of the œsophagus and through the subcutaneous portion of the skin tube, care being taken not to penetrate either the œsophageal wall or the epidermis of the skin tube. Following this procedure the triangular flap is then brought over the point of anastomosis of the œsophagus and the skin tube, and the wound closed.

skin tube (Fig. 12). The suture of the œsophagus with the skin tube is accomplished by interrupted sutures passing through the subcutaneous tissue of the skin tube and barely catching the wall of the œsophagus, care being taken not to penetrate into the lumen of the œsophagus or to pass through the epidermis of the skin tube. In this way salivary secretions are discharged into the lumen of the skin tube without any danger of their coming in contact with the suture line. The possibility of a fistula is thus greatly minimized. The skin flap is then replaced over the suture line, after placing a drain into the mediastinum.

Because of the possibility of mouth contamination, it is well, if the patient shows any evidence of infection, to look for the possibility of Vincent's infection; and even if such is not found, it seems advisable to give neoarsphenamine as a prophylactic procedure. It is obvious that a patient with an impermeable stricture with accumulation of saliva in a blind pouch might have spilling over into the trachea from time to time and that this may be a predisposing factor in the development of bronchiectasis. Undoubtedly, the spirocheal infection which we had in the cervical wound of our patient was the result of a bronchiectasis, and we are of the opinion that this complication occurs more frequently than has been recognized. In such infections we have found it of distinct benefit to combine the intravenous administration of neoarsphenamine with the topical application of arsphenamine and gentian violet.

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DISCUSSION.—DR. CARL EGGERS wished to report briefly on a patient who was recently operated upon, on account of gradually developing symptoms of œsophageal obstruction. He had been kept under observation for some time, and in spite of everything we did and notwithstanding a gastrostomy which was performed to put the œsophagus at rest and allow the lesion a chance to heal, the obstruction became total.

Several biopsies failed to give positive evidence of carcinoma, but the reports of the röntgenologist and endoscopist were in favor of carcinoma and it was decided to operate. We resected the œsophagus according to the method described by Doctor Torek. When the specimen was examined we found an ulcer, two and one-half inches in length, and involving almost the entire circumference of the œsophagus. On microscopical examination it was reported to be a chronic ulcer.

We were naturally somewhat upset by this finding as we had anticipated an early carcinoma, since it has been our experience that a patient who presents gradually developing obstruction as the principal symptom eventually has usually been proven to have a carcinoma. The important point is that the patient recovered. He was recently presented before the New York Surgical Society and will be reported in detail in its transactions. The patient has now a rubber œsophagus connecting the upper œsophagus stump and the gastrostomy. It permits him to masticate and swallow food normally. The muscles of deglutition are sufficiently powerful to send all fluid foods down into the stomach without difficulty. With solids there is at times a little stagnation, even though an extra quantity of fluid is taken to wash them down. To overcome this one of our assistants has interposed a rubber bulb into the rubber œsophagus which permits slight pressure to be made and facilitates the passage of food. The patient is now able to eat almost anything.

The question arises whether we shall be satisfied with present conditions or whether an attempt at plastic reconstruction of the missing portion of œsphagus shall be made. The patient is somewhat over forty years of age. He has an œsophagus stump buried in a subcutaneous channel on the upper left chest wall. He likewise has a Janeway gastrostomy. Both tubes are lined with mucous membrane and it has seemed to us that the formation of a subcutaneous skin tube to connect the œsophagus with the gastrostomy, similar to the operation described by Doctor Ochsner, might be attempted in this case after he has regained his normal weight.

THE TREATMENT OF EMPYEMA*

By John F. Connors, M.D.
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It is a great impetus to the study of empyema to have it discussed from various angles. One recalls how, years ago, there was never a meeting of the American College of Surgeons where appendicitis was not discussed by Murphy, Oschner, and others. It might be well to bring to the attention of the profession at large the seriousness of empyema as these men did appendicitis.

Previously we looked upon the operation for the cure of empyema as a case for the house surgeon, and now in retrospect we can see why our mortality was as low as it was; only because of the fact that the diagnosis was not made until the pleura contained thick pus and adhesions had formed which stabilized the mediastinum. Most of us can recall the frightful mortality in cases of empyema in France while open thoracotomy was in vogue and how it was reduced when frequent aspirations were substituted.

We have learned much since we first began this method as to the time when operation is indicated. I assume all the responsibility for our early mistakes due to the desire to operate too early, which I realize now was unjustifiable. Much of our knowledge has come from the work done by the Thoracic Service at Harlem Hospital which changed our concepts of this condition. At present we find waiting until real pus and adhesions are formed essential, and we have had some cases in which no other procedure was instituted and the cases cured. The results obtained in the packing method for chronic empyema have been shown before this society and need no further comment.

We are firmly convinced, if this method be used, we shall see the end of chronic empyema sinuses which are a bugbear to the surgeon and to the patient, and have existed for years with little hope of complete recovery.

The method of treatment of acute empyema thoracis employed at Harlem Hospital at present, is essentially the same as described by us in the Annals of Surgery, July, 1931. It has proved to be the simplest and best method in all our experience. It has been tried by other surgeons with favorable results. Unfavorable criticism has come from some who have not employed the method and have not seen it employed. In view of the fact that the procedure at first glance seems extensive and radical, this attitude is conceivable but reprehensible.

Operative Procedure.—An incision is made along the line of a rib over the central portion of the empyema cavity. Two or three inches of two ribs, as a rule, are removed subperiosteally. In a case of a very small localized collection of pus the removal of a portion of one rib may suffice. Intercostal muscles, vessels, and nerves are removed *en masse*. The empyema cavity is gradually opened and finally the parietal pleura and endothoracic fascia is cut away

* Read before the New York Surgical Society, March 14, 1934.

leaving a window into the pleural cavity about two inches in diameter. The pleural cavity is cleared of pus and fibrin and if there are several lobules they are made into one. Packing is then inserted into the entire cavity with fairly firm pressure. Occasionally firm pressure in the pleural cavity against the pericardium may cause embarrassment of the heart and acceleration of the pulse. This may be obviated by light packing or its early removal. While at the beginning of our series the pleural cavity was repacked frequently it is now the practice to remove the packing on the second or third post-operative day and, with rare exceptions, not to repack. Previously iodoformized gauze was used, but this has been abandoned in favor of plain gauze since it was occasionally toxic. Gauze packing depends not upon its antiseptic quality but upon mechanical pressure for its action. After the packing has been removed only superficial dressings are required down to, but not into the pleural cavity. Great care must be exercised in maintaining an orifice in the chest-wall until the lung has expanded.

We believe "the packing method" is the best procedure at our command, but despite that we do not apply it invariably. In five cases intercostal drainage was used, one of these patients died, three were cured and one required thoracotomy and packing. In the few extremely toxic and seemingly moribund cases it is advisable to institute intercostal drainage first and then proceed with thoracotomy and packing if cure does not ensue.

The advantages of the packing method are:

1. Adequate exposure is obtained of the entire infected pleural cavity. Under direct vision the cavity may be thoroughly cleaned.

2. Fibropurulent material attached to visceral and parietal pleuræ is removed by the pressure of the gauze. This makes a clean-walled cavity and by removing the pyogenic membrane allows the lung to expand more easily.

3. It reduces to a minimum the presence of foreign bodies in the pleural cavity and obviates entirely the use of irrigating fluids. Tubes and irrigating fluids frequently irritate the infected pleura and prolong infection and fever.

4. The economy of material and labor is considerable. Dressings are infrequent and are extremely simple.

A résumé has been made of all cases treated dating from the report in the ANNALS OF SURGERY in July, 1931. There have been seventy-four cases operated upon with five deaths, a mortality rate of 6.6 per cent. Fifty-five patients were adults and nineteen were children. The cases in which bacteriological examinations were made showed pneumococcus in forty-one, *Streptococcus hemolyticus* in fourteen, non-hemolytic streptococcus in one, staphylococcus in five and mixed infection in one.

In the case of five patients who died, pneumococcus was isolated in two cases, hemolytic streptococcus in one, a short chain streptococcus in one, and in one the bacteria were not identified. Two of these patients were children and three were adults. Instead of recording further purely statistical data, it will be of greater interest perhaps to inquire into the causes of death in these five cases.

CASE I.—Catherine B., aged thirty-one, was admitted to the hospital December 25, 1933, on account of lobar pneumonia of the right lower lobe. Empyema developed on the same side and January 11, 1934, thoracotomy was performed. A large quantity of pus was evacuated and the pleural cavity was packed. A pneumococcus was isolated from the pus. The immediate post-operative recovery was excellent. For four days the temperature averaged 100°–101°, the pleural cavity became clean and dry. The patient felt well. On the fifth day the temperature rose and remained elevated until the time of her death. A bronchopneumonia had developed in the opposite lung, that is, in the left lower lobe. February 22, 1934, she was transferred to the medical service because the empyema required little care while the pneumonia was spreading rapidly through the left lung. The process clinically progressed like an acute tuberculous lesion but tubercle bacilli were not isolated, though sought for. Ten days after the transfer to the medical service the patient died. At the time of her death (seven and a half weeks after operation) the empyema cavity was closed and the wound required very superficial dressings.

CASE II.—Albert C., aged twenty-four, was admitted to the hospital May 6, 1931; was operated upon May 12, and died May 24. The admission diagnosis was left pleurisy with effusion, the origin of which was not determined. The fluid became rapidly purulent and thick. *Staphylococcus albus* was isolated. Thoracotomy was performed with evacuation of a large quantity of thick pus. The patient did well for ten days. During that time the temperature reached normal, the empyema cavity became quite clean, the lung reached the chest-wall on coughing and the patient felt well. At the end of this period of ten days the patient developed an overwhelming pleuropulmonary infection in the opposite or right lung. The pleural cavity rapidly filled with fluid so that the exact nature of the pulmonary lesion could not be determined. May 22, 775 cubic centimetres of thin purulent fluid were aspirated and the following day 500 cubic centimetres. A streptococcus in short chains was isolated from this fluid. May 24 the patient died. In the two days before death he showed signs of the most severe and most rapidly fatal infection I have seen. It was reminiscent of the worst of the wartime epidemic influenza cases. At the time of his death the empyema cavity was quite clean and the lung came out well to the chest-wall on expiration.

CASE III.—Nann P., aged twenty-one, was admitted to the hospital April 18, 1932, on account of a miscarriage. She developed a right lower lobe pneumonia followed by empyema from which was isolated an hemolytic streptococcus. The patient died twelve hours after operation. She was so septic that novocaine was employed for anæsthesia although avertin is used routinely.

CASE IV.—Claude C., aged thirteen months, had a right lower lobe and a right middle lobe pneumonia. He had recently recovered from chickenpox. At the time of operation he had acute pharyngitis and acute purulent left otitis media. He was anæmic and marasmic. In addition to an empyema he developed an abscess of the chest-wall. Admitted to the hospital June 9, 1933, he was operated upon June 16 and died July 6, 1933. His condition was so desperate that the chest-wall abscess was operated on and pleural drainage obtained through the same incision by means of a tube thrust through an intercostal space. In spite of careful supportive treatment the child gradually declined and died twenty days after operation. An X-ray picture demonstrated a partial pneumothorax (about one-half) and a collection of fluid about three-quarters inches in height. The organism was not identified in this case further than that it was a Gram-positive coccus in single and diplo forms.

CASE V.—Martin W., aged two years, developed empyema following a right upper lobar pneumonia. He was admitted December 4, 1933, operated upon December 13, 1933, and died twenty-seven days later. He was a puny child but improved for the first few days post-operative. The pleural cavity soon became quite clean. On the fifth day post-operative an impetigo contagiosa appeared and spread upon his face. An acute nephritis developed, after which the child lost ground rapidly and died.

Cases I and II are interesting types. They are very similar in that they are both cases in which an empyema was well drained and in which the patients were apparently on the road to complete recovery, when they were carried off by a severe contralateral lung infection. In our patients who are so frequently in miserable physical condition, it is remarkable that this contralateral pulmonary infection does not occur more frequently. It is a complication of empyema before which the surgeon is helpless. In Case III, in which there was an overwhelming toxemia following the miscarriage and pneumonia, better judgment might have dictated an intercostal closed system drainage rather than thoracotomy and packing. In Case IV the patient died even though merely intercostal drainage was instituted and good drainage obtained. This child was in such poor condition that he could not combat even the mild infection that remained after drainage was obtained. Case V demonstrates death caused by factors unrelated to the empyema.

An analysis of the various statistical data related to the subject of empyema is of interest, namely: age, sex, bacteriology, seasonal incidence, epidemiology, duration of post-operative pneumothorax, *etc.*, but more important than all of these is the mortality table. On that account we have laid stress upon the deaths. We believe we have considerably lowered the mortality in empyema at the Harlem Hospital by the method of open thoracotomy and packing of the pleural cavity. We believe the method works almost uniformly, regardless of the factors of bacteriology, of age, *etc.*, and recommend this really simple method to those who are interested in having first of all a live patient.

Dr. Evarts Graham, at the last meeting of the American Surgical Association, said: "The first object in the treatment of empyema is to save the life of the patient. The second is to shorten the convalescence as much as possible." He assigns the principal cause of death to the injudicious use of open pneumothorax. With all this we agree and we believe that no method of treatment is more in accord with these canons than the packing method.

OBSERVATION ON CHRONIC EMPYEMA*

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Articles that have appeared during the last ten years by Eggers,[5] Hedblom,[4] Graham[3] and others and the comprehensive monographs by Muller[6] in Lewis' Surgery and Heuer[7] in Nelson's Surgery have covered the subject of acute and chronic empyema so completely that I approach the subject reluctantly. I have little to contribute, and that little is, to some extent, at variance with views expressed by these writers of wide experience.

I shall confine myself, therefore, to features that have arrested my attention as I have watched for the past forty years patients operated on for acute and chronic empyema, and as I have noted the curious oscillation in the estimate of worth of the methods of treatment.

I use the word oscillation to indicate the swing to and fro of opinion without advance from the rediscovery of the advantages of closed siphon drainage by men born some years after its introduction and enthusiastic recommendation, to the equally zealous advocates of the advantages and excellent results from open drainage, in like manner forty or fifty years after its first introduction.

As a matter of fact, if the opinions on treatment of acute empyema expressed by Delafield[1] forty years ago, or by Strümpel,[2] be compared with the views expressed by Graham[3] last year, the agreement is striking. It is in accord with the views of most observers with wide experience.

The general therapeutic practice is thus summed up in one of the textbooks: "At the present time (1890) the rules for treatment are definitely determined and give satisfactory results. In children under ten years of age a certain number of cases can be cured by aspiration alone. If, however, the inflammation continues after three aspirations, the chest must be opened and drained. It is not usually necessary to remove any of the ribs. In sacculated pleurisy, if it is of small size, aspiration alone will often effect a cure. It is curious to see the complete cessation of serious symptoms after the aspiration of only half an ounce of pus. In adults with an empyema of any size the chest must be opened and drained and one rib resected. Different surgeons have different methods of operating, but they all get good results if the pleura is not infected."

There has also been general agreement that it is undesirable to attempt to resect a rib in sick patients suffering from streptococcus septicæmia with multiple lesions, or while an active lesion still persists in the lung. For no surgeon cures generalized infection by mechanical measures. He accomplishes striking and most satisfactory results, if he intervenes at a certain stage when general resistance has been well established, localization has occurred and a

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purulent exudate has accumulated under tension. He may, to be sure, from time to time, by judicious minor procedure, such as aspiration, aid to a slight extent the body to combat general infection.

It has been pointed out many times[3, 4, 5, 6, 7] that the mortality fell in a striking manner during the World War when closed drainage was substituted for open drainage. But I doubt if the variation in the virulence of infecting microörganisms, the lesions found at autopsy, the interval of time between the operation and death, or what is meant by open or closed drainage, has been sufficiently considered in making this statement.

It cannot be too strongly emphasized that operations for drainage of empyema will not cure general streptococcus sepsis, nor will the drainage of one abscess, when others exist. The emphasis, a few years ago, on the danger of open pneumothorax and not on this very obvious fact seems to me unfortunate. It led, through fear of creating an open pneumothorax long after such a danger had ceased to exist, to insufficient drainage and the creation of thickened pleura and chronic empyema.

It is generally recognized that pyogenic infection in the tissues, after sufficient resistance has been produced in the body to insure localization, regularly heals soundly, provided that a free outlet is made for the purulent exudate and that failure to heal, that is to say, the persistence of infection is due to definite and recognizable causes and that a removal of these is promptly and regularly followed by cure even after the infection has been established for years in the tissues. Persistence regularly follows when a cavity is found in the body with walls so firm and unyielding that the force of the contracting new tissue at the junction of the walls of the cavity where the granulating surface comes in contact with granulation surface is not sufficient to initiate obliteration. Such a cavity with rigid walls is the underlying morbid condition in chronic pyogenic empyema.

Foreign bodies, osteomyelitis of rib and necrosis of cartilage, bronchial fistula, small abscesses in the depth of the thickened pleura and defective drainage are commonly given as inciting agents for this condition. But osteomyelitis and necrosis of cartilage are causes of persistent thoracic fistulæ which may or may not be present in addition to an empyema cavity. Foreign bodies, usually drainage tubes, readily fall into empyema cavities rather than cause them.

The small abscesses found in the depth of thickened pleura occur not infrequently in the walls of any imperfectly drained abscess. They are the result, not the cause of chronic empyema. They indicate the invasion of the wall of a chronic suppurating cavity produced by dammed-in exudate.

If the purulent exudate in the empyema cavity finds partial exit through the lung, a bronchopleural fistula is formed. Again, if a lung abscess ruptures into the pleura, a bronchopleural fistula results and the pleura is infected. In either event, after drainage, a communication exists between the suppurating pleural cavity, the lung and the external surface. The pus in the empyema cavity drains partially externally and partially through a bronchus. Violent

expiratory effort forces air out of the bronchopleural fistula rather than causes the lung to expand. But obliteration of the empyema cavity and the freeing of the lung usually results in the healing of the fistulæ. The cure of the fistulæ is accomplished by curing the chronic empyema. It is usually a complicating condition, rarely the cause of chronic empyema.

Finally, defective drainage does not seem to me to express sufficiently well the underlying pathological law which inevitably leads to the conversion of an ordinary acute empyema cavity with yielding walls to one in which the walls are so rigid that the forces bringing about the expansion of the lung can no longer act. The causes given for the expansion of the collapsed lung in acute empyema are: (1) The pull of the contracting granulations at the reflexion of the parietal pleura on the visceral pleura as the two layers fuse; (2) the positive pressure in the trachea and bronchi brought about by the sound side, during forced expiration driving air into the collapsed lung and causing it to expand; (3) the negative pressure in the empyema cavity present during inspiration when the diameter of the drainage opening is smaller than that of the main bronchus.[8]

It is evident that these factors are brought into play only when the walls of the abscess cavity yield sufficiently to permit them to act. Therefore a chronic empyema is created with little or no tendency to heal as soon as the walls of the new formed connective tissue replacing the pleura are sufficiently thick and inelastic to prevent the lung from expanding and to initiate healing at the angle of reflexion.

The thickness of the wall is dependent, as in all abscess cavities, on repeated small reinfections and secondary infection. Reinfection occurs as the result of the slightest interference with the free outflow of the exudate. Under the anatomical conditions that exist in the pleural cavity, it is an extraordinarily delicate reaction. Granulations are organized, new tissue laid down under repeated infections so slight that they can be easily overlooked clinically. Moreover, the incision made to allow the purulent exudate to escape has a tendency to heal faster than the large abscess beneath it.

For this reason, I do not believe it is sound teaching to state that chronic empyema can be prevented by retention of the drainage tube indefinitely, or by not changing the diameter of the tube, or by applying continuous suction drainage. I believe a chronic empyema might easily be produced by making a puncture wound into a normal pleural cavity and applying suction for weeks and months.

Despite meticulous care, sooner or later the pleura would be infected by organisms gaining entrance about the drainage tube. The effort to make a tight joint where the tube passed through the chest-wall would inevitably result in some of the exudate collecting between the tube and the granulating wall surrounding the tube, and time after time the purulent exudate and infecting pyogenic microörganisms would gain entrance into the pleural cavity. Further, the large size of the resulting suppurating cavity might easily

furnish an exudate more abundant than could be carried off freely by the tube.

Therefore, if there is evidence of a considerable empyema cavity four or five weeks after the operation for drainage of the purulent exudate, and if the tissues are firmly healed about the tube, it is well to operate a second time and remove a portion of the rib above or below the original drainage, according to the position of the underlying cavity.

The careful supervision of the treatment of empyema in the subacute stage is very important. It is during this period that conditions leading to chronic empyema can and should be avoided. For granulations that line the suppurating cavity are not readily infected as long as the serum, cells, bacteria, tissue detritus, *etc.*, that make up the exudate, are given free exit. The slightest backing up causes reinvasion of the tissue by the bacteria originally causing the infection and others that have secondarily lodged and proliferated in the exudate.

Obviously similar laws govern any secondary abscess draining through a narrow passageway into the main empyema cavity. For the purulent exudate may be shut between the lung and thoracic wall, between lung and the diaphragm, the lungs and the pericardium, and between the lobes of the lung. Hindrance of the free outflow of the purulent discharge in a secondary cavity results inevitably in more invasion of wall and more protective response in the surrounding tissue.

There are countless case reports, especially in the older records, where no exit had been made for the exudate. In most instances pus collecting under pressure found its way eventually through the thoracic wall or into the lung or into the peritoneum or the retroperitoneal tissue, but such opening did not occur until there had been sufficient reaction in the connective tissue of the pleura to create a rigid walled cavity and a chronic empyema resulted. There are even instances in which the pus never escaped. It was shut in by enormously thickened connective-tissue walls and finally gave no evidence of its presence. The pyogenic organisms had died or become quiescent. A condition was reached similar to the circumscribed abscess in bone. Such shut-in collections of pus have been found at autopsy. A time relation therefore exists dependent on the length of the period in which the purulent exudate has collected under tension in the empyema cavity and expressed in the thickness of pleura.

Chronic empyema implies attenuated infection, or such as might readily occur, with intermittent discharge slightly slower than accumulation, or undrained discharge. Obviously virulent infection with rapid invasion would result in very different clinical pictures. It also implies the establishment of considerable resistance on the part of the infected subject. The essential cause of chronic empyema is the organization of the granulation tissue replacing the pleura under the stimulus of repeated infection.

The treatment aims at providing such free drainage that reinfection is avoided and at substituting for rigid walls, ones yielding sufficiently to initiate

healing. The first object, and the second to slight extent, were plainly in the minds of a number of surgeons between 1870–1879. Estlander,[9] Schede,[10] and a number of other surgeons succeeded in curing chronic empyema by drainage and removal of several ribs. But Schede as early as 1878 observed that in a number of instances the failure to heal resulted from the unyielding nature of the parietal walls left after the ribs had been removed.

He published in 1890 an interesting series of cases. In his effort to make a wall that would bend and come in contact to some extent with the pulmonary pleura, he resected the whole length of the ribs from costal cartilage to the tubercle. In several instances all of the ribs from the second to the ninth were removed. He then cut away the thoracic wall left after the removal of the ribs, a wall often 2 to 3 centimetres thick, made up of the dense connective tissue replacing the parietal pleura fused with the intercostal and subcostal tissues. In every case an attempt had been made to heal the cavity by less radical measures and in most instances the extensive resection was carried out in two or three stages. In seven of thirteen cases reported, sound healing resulted from resection of the ribs. Five were cured by extensive thorax resection. There was one death from iodoform poisoning on the sixth day. In every instance the cavity left after operation had been stuffed with iodoform gauze.

Two years later, Delorme[11] reported healing of chronic empyema by a method he had suggested several years before. To avoid the deformity resulting from the resection of the chest-wall, he suggested, and in one instance carried out, the removal of the pulmonary pleura, so that the inner wall of the rigid cavity would become yielding and the expanding lung would fill the cavity. A large U-shaped thoracic flap was mobilized, the thickened connective tissue binding down the lung was incised and separated from the underlying lung by blunt dissection. The lung expanded. The flap was sutured in place. The patient recovered from the operation, the chronic empyema was cured. The patient died one year later, however, from cerebral and abdominal tuberculosis.

The modern method combines the two methods. It may be spoken of as the Schede-Delorme operation. It is carried out slightly differently by different surgeons and the procedure varies according to the extent of the cavity, the ease with which the lung can be separated from the connective tissue binding it down, and the capacity of the lung for expansion. The trend of practice by the best operators seems to be to avoid extreme deformity by efforts towards mobilization of the lung and by limiting the resection of the ribs. The results published by Eggers[5] in 1923 were most satisfactory and the resulting deformity, considering the nature of the lesions, surprisingly slight. He reported ninety cases with but one death.

In describing the morbid anatomy and the treatment of chronic empyema I have not used the term "thickened pleura." For, if one examines a section of the lung and the dense adherent tissue, it has the appearance of organizing granulation tissue with its inner surface covered with pus and fibrin. There

is no endothelial layer. The pleura is replaced by connective tissue which has been laid down in layers. There are lines of cleavage between these layers. In many instances as the tissue is incised, a layer is finally reached, sufficiently thin to enable one to see the grayish lung beneath; and when this layer is reached the lung may begin to expand. Further dissection may separate the lung so exposed from its dense covering but the so-called thickened pleura does not peel off as one peels the skin of an orange.

And I have used the words "initiate healing" advisedly, to express how these measures bring about the obliteration of the cavity and cure of the patient rather by starting a process leading to recovery than by complete removal of an infected membrane or by completely obliterating the cavity.

A very considerable number heal soundly if the ribs are resected, and free drainage established with or without some method of antiseptic irrigation. As healing starts and the cavity is obliterated, there is a resolution of the dense connective tissue so that the lung again becomes active and the X-ray no longer shows the opaque tissue replacing the pleura. Again, one-half of the pyogenic membrane is not removed in the Schede operation and the other half is not removed in the Delorme operation, yet sound healing results in both methods. Moreover, the modern operation which uses both methods does not remove all of the pyogenic membrane, nor is the cavity completely obliterated, yet healing occurs and thickened membrane disappears. What I believe is accomplished by any of the measures is enough yielding on the part of the abscess wall to start healing, and as healing progresses the dense tissue replacing the pleura gradually disappears just as it disappears under similar conditions in the peritoneum, provided reinfection is avoided.

The plan I have followed in the treatment of patients has been based on these considerations. Of the twenty-six patients which I have operated on for chronic empyema, twenty were cured. The fistula healed; the empyema cavity was obliterated; the lung expanded to a varying extent and the thickened pleura was no longer evident. Two of these patients, however, had a recurrence, one due to an overlooked costophrenic diverticulum from the main empyema cavity. An abscess formed and discharged intermittently through the old cicatrix. The patient remained in good health and was able to lead an active life and earn his living. He was operated on two years ago, twenty-one years after the operation for chronic empyema. The overlying rigid wall was removed and the small residual cavity drained. Sound healing resulted. The patient now weighs 180 pounds. The second patient had a medium-sized cavity. After a resection of four ribs and the corresponding portion of chest-wall, the remaining cavity was treated with Dakin solution, rigorously applied after the method introduced by Carrel. The wound was allowed to close when smears showed one organism in ten fields. X-ray showed the lung expanded and no thickening of the pleura. The patient led an irregular life and became alcoholic. Fifteen years afterward he had pneumonia and following this, an empyema on the same side as the original lesion. A rib was

resected and he still has a small fistula. On account of his feeble condition, further operation has seemed undesirable.

The gain in weight in many of the patients has become astonishing. They were evidently exceptionally vigorous individuals. Foreign bodies were found in five. Two drainage tubes were removed from one cavity, one from another, four very foul-smelling black sequestra had fallen into the cavity in a third and calcareous masses were found in the fourth and fifth.

In several there was a severe reaction after operation, with high temperature. In one case the operation was followed by general dissemination. Streptococci were found in the blood-stream. The evening temperature two days after operation was 107°. The patient developed phlebitis and an abscess of the hip, but finally recovered. The cavity in this instance was very small and the operation limited.

I believe preliminary repeated irrigation with antiseptic solution, preferably Dakin solution, is of advantage. It reduces temporarily the number of microörganisms in the discharge. I do not believe it hastens recovery or promotes dissolution of the thickened tissue after operation. I have not found that the patient in which it was used did better than the one in which it was not used. Recovery seemed to depend much more on how completely I had been able to create mechanical conditions favorable for healing. My failures have been due to overlooked byways and pockets and rigid residual cavities.

Six of the patients have not been cured. Five recovered from the operation, regained to some extent their health and strength but had a residual cavity and a fistula persisted. In four of these I assumed that the risk of further operation was greater than the inconvenience suffered from the persistent fistula. One of the patients died some months later from chronic nephritis. I have had but one death. The patient had had a lung abscess which had ruptured into the pleura. I attempted to resect and close the pulmonary fistula at the same time that I performed an operation for obliterating the empyema cavity that still persisted after two operations.

In every instance I have removed a portion of thoracic wall after rib resection. I have regularly limited the resection to a portion only of the roof of the underlying cavity, and have preferred two or three operations, where extensive resection was necessary. I have usually attempted the removal of a portion of the pulmonary pleura. In doing this I have found it difficult to determine the position of the pericardium, heart, lung and diaphragm. The large floor of the cavity has looked uniform with no salient structures. I have, therefore, first scraped away, without force, the detritus and purulent material and wiped the surface with gauze, then palpated to determine the position of heart and diaphragm and examined carefully to determine the presence of diverticula and secondary cavities. I have then made an incision over what I assumed was the lung through the thickened tissue until the bluish-gray surface of the lung showed through a thin layer of tissue. By blunt dissection, aided by the gloved finger, I have made an effort to separate

lung from overlying tissue and to cut away as much tissue as has been freed. If this was accomplished easily, the lung expanded; if with difficulty, I have been content to remove a strip, or simply to extend the incision. I have gone on the principle that the membrane in pyogenic infection was similar to the wall of any abscess and that the difficulty in healing lay not in the infected wall but in its rigidity and if the wall could be made yielding even to a slight extent, healing would start. In contrast, if there is a secondary pyogenic infection superimposed on tuberculosis of the pleura, I believe it is of much more importance to remove as far as possible the infected membrane, for the law governing the healing of tuberculous abscess, secondarily infected, is different from the law governing the healing of a pyogenic abscess. However, as the subject of tuberculosis is treated by one of the other speakers of the evening I shall not attempt to discuss this subject. I have never believed in the method, suggested by Ransohof, of making longitudinal incisions and cross incisions, because if the lung expands after such incisions it indicates that the lung is not so firmly attached to the overlying tissue that the thickened tissue cannot be separated and removed. I have never attempted an extensive sharp dissection of both the parietal and pulmonary pleura as advocated by Eggers.[5]

I have always sutured the soft parts and introduced a large drainage tube, then applied a damp antiseptic dressing. This does not hinder the free outflow of air and pus from the cavity but does hinder the entrance of air with inspiration. This relation is as important in the after treatment as it is in the after treatment of acute empyema. All the means available to insure forced expiration and thus aid in driving air into the lung on the side involved, have been regularly carried out. Abstracts of the histories and the X-ray findings in twenty-one of the cases referred to were published in the Transaction of the American Surgical Society (1920).

Summary.—I believe the cause of chronic pyogenic empyema lies in the reaction of the tissue to repeated slight infection of the pleura; that such infection can be avoided by careful supervision of the treatment of the empyema cavity during the subacute stage; that a secondary operation with the removal of rib, and free drainage, will prevent extensive later operations; that when chronic empyema has developed, surgical measures result in the starting of healing and the gradual obliteration of the cavity by making to some extent the rigid walls yielding, and finally that the residual thickened pleura resolves and becomes thin when the cavity is obliterated.

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PUTRID EMPYEMA*

RUPTURED PUTRID ABSCESS OF THE LUNG

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There are distinctive features in pathogenesis, pathology, diagnosis, and treatment which distinguish putrid empyema from other pleural infections. Nevertheless, the lesion has not received the consideration which it merits in the numerous contributions which have dealt with pleural suppuration. Most authors apparently regard the condition merely as a variant to be noted in passing, if, in fact, they mention its existence, and have advocated no treatment that differs from that employed for other empyemata. We propose to show that putrid empyema is a definite entity deserving of separate consideration and that effective treatment can be best instituted by an appreciation of its pathogenesis, pathology, and clinical manifestations.

Putrid empyema will be shown to be the result of the rupture of a putrid (anaërobic) abscess of the lung into the pleura. The term is therefore not truly descriptive and is employed only for convenience. The complication is not to be regarded as a rare accident. In children putrid empyema was encountered seventeen times in 184 consecutive cases of pleural infection[1] and is met more often proportionately in adults. Its incidence as a complication of putrid pulmonary abscess is shown by its occurrence in twenty-five of 100 consecutive cases of abscess of the lung. There are other lesions which may occasionally lead to putrid infection in the pleural cavity. Among these may be mentioned putrefaction after intrapleural hæmorrhage, necrosis of the lung following infarction or trauma, and pleural invasion from a putrid subphrenic abscess. Those and other adventitious forms of putrid suppuration within the pleura are not under consideration in this paper.

Pathogenesis and Pathology of Abscess of the Lung.—Before presenting the subject of putrid empyema, some aspects of our concept of the pathogenesis and pathology of putrid pulmonary abscess[2] should be referred to since the views to be presented on the diagnosis and treatment of putrid empyema are based thereon. Putrid abscess of the lung is initiated by the aspiration of infective particulate material into and its arrest in one of the smaller bronchi. In two-thirds of the cases the probable episode of aspiration is known (as after tonsillectomy or tooth extraction), but the etiology is not obvious in the remaining third. In other words, putrid pulmonary abscess occurs after known or assumed aspiration in previously normal individuals.

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An intense necrotizing gangrenous process is set up at and distal to the site of arrest of the infective material in the small bronchus. A well-defined gangrenous abscess of the lung develops within a few days. Although we recognize the occasional occurrence of diffuse gangrene of the lung under unusual circumstances (submersion, for example) our observations of the pathological lesions in many cases lead us to believe that a commonly held view of the onset of abscess of the lung as a more or less diffuse area of gangrene in the midst of a pneumonic consolidation is erroneous. The abscess is always situated near the surface of the lung and the overlying pleura becomes involved in an inflammatory process with resultant adhesions. Early, severe, localized chest pain at the site of pleuritis is therefore an almost invariable phenomenon. Foul sputum is pathognomonic of abscess of the lung, and occurs in the great majority of cases. Characteristically its onset is on the tenth to twelfth day of illness.

It is particularly germane to the subject of putrid empyema to state that foul expectoration does not occur in all cases; may be present transiently at the outset and not recur; may recur from time to time, or may be suddenly reduced or disappear coincidentally with an unfavorable change in the patient's condition. Further consideration of the pathological process will account for these variations. The bronchus originally infected always communicates with the abscess in the lung, but congestion and œdema of its walls may prevent the egress of the pus completely or intermittently. As already stated, the abscess is always situated near the surface, and only a shell of lung and adherent pleura separates it from the free pleural cavity. Penetration into the free pleural space is therefore a possibility in every case of abscess of the lung and the sudden reduction or disappearance of foul expectoration coincident with signs and symptoms of pleural extension indicates that this accident has occurred. An important group of cases in which foul expectoration does not occur, or is transient and insignificant should now be noted, for this group is particularly related to our subject. We refer to the small subpleurally situated abscess derived from a very small order bronchus, which we have termed "cortical abscess." On the one hand, spontaneous cure through drainage via the bronchial communication can readily take place. On the other hand, early rupture into the pleural space can occur quite as readily.

Considerably more than half of our cases of putrid empyema were due to the rupture of an acute abscess of the lung. Pleural invasion is by no means uncommon in the subacute or chronic stages. The pathology of chronic abscess of the lung is characterized by the presence of multilocular cavitation with surrounding fibrosis and bronchiectasis. Slow perforation through fibrotic lung tissue with sharply encapsulated putrid empyema may occur. Another variety is rupture into the free pleural space adjacent to dense pleural adhesions. A third form is rupture of a secondary bronchiectatic focus in the neighborhood of the abscess. And, finally, spillover infection from the chronic abscess to another segment of the lung may lead to the sequence of acute abscess of the lung and early perforation into the free pleural space

at that segment. This complication may develop in the same lobe or in another lobe on the same or on the opposite side.

The Pathology of Putrid Empyema.—This varies to some degree in accordance with that of the underlying acute or chronic abscess of the lung. The variations that may occur have been indicated, and will be referred to again. The general characteristics of putrid empyema can be described briefly. The contents consist of foul pus and detritus, gathered in one or more compartments. Aërobic cultures are usually sterile. Foul air is often present, the amount depending on the size and patency of the bronchial communication at the site of rupture of the abscess of the lung. Although the bacteria of putrid abscess of the lung are anaërobic,[3] the organisms are not to the best of our knowledge gas-producing in the abscess of the lung or in the complicating empyema. A putrid empyema, therefore, may contain no air if the pulmonary abscess from which it has been derived is shut off from its bronchus. The lining of the empyema cavity is intensely inflamed, hæmorrhagic, and not infrequently gangrenous. For this reason the site of the ruptured abscess of the lung may not be seen at the time of operation but a bronchial fistula can almost always be demonstrated when the pleural infection has subsided. Although a putrid empyema may occupy practically the entire hemithorax, it is ordinarily of more limited extent. An interesting pathological feature of putrid empyema, and one that is of vital importance in treatment, is the fact that the mediastinum is usually steadied by visceroparietal pleural adhesions regardless of how large the collection of pus may be. Marked shift of the mediastinum is so rarely seen in putrid empyema that, for practical purposes, its occurrence need not be taken into account. A contrasting pathological feature that is of equal clinical significance is the tendency towards later destruction of adhesions. Whereas localizing adhesions are characteristic of the early stage of putrid empyema, their subsequent fate is apt to be quite different from that of the pleural adhesions in aërobic empyema. In the latter, adhesions usually become thicker and denser during the evolution of the suppurative process; in putrid empyema they tend to disappear apparently because of the liquefying effect of the anaërobic infection. There is, therefore, an ever-present danger of the escape of an encapsulated putrid empyema into the general pleural space.

The clinical manifestations of putrid empyema obviously will vary in accordance with the characteristics of the underlying pulmonary focus and the extent and intensity of the pleural infection. The discussion will be based on an analysis of our clinical material, consisting of fifty-one cases. The cases fall into three groups: ruptured acute abscess (twenty-five cases), ruptured chronic abscess (sixteen cases), and putrid empyema following operations for pulmonary abscess (ten cases). Each group warrants special consideration because of differences in clinical manifestations, diagnostic features, and treatment. Most consideration will be given to ruptured acute abscess of the lung. The operative treatment of all forms of putrid empyema will be de-

tailed under that caption. Only the variations in treatment which are required in the other forms will be described under their respective headings.

RUPTURED ACUTE ABSCESS OF THE LUNG

This is the most common cause of putrid empyema. From the viewpoint of therapy it is perhaps the most important. We may say at once that it may be difficult or even impossible to recognize the existence of a putrid empyema until exploratory aspiration reveals the presence of foul pus. There are, however, some features which may lead to a correct and, more particularly, to a relatively early diagnosis in the majority of cases, if the condition is borne in mind. Early diagnosis is to be stressed because our experiences indicate that recovery is, at least in part, to be ascribed to early surgical treatment.

The etiology is unknown in the great majority of cases. There were a few instances in which tonsillectomy, tooth extraction, or acute tonsillitis antedated the pulmonary invasion. For the most part, however, the onset bore no relation to any obvious previous condition. The common co-existence of pronounced periodontal tartar has led to the belief that aspiration of particulate material from this source is the etiological factor in many cases.*

The onset, early symptoms, and physical signs closely resemble those of pneumonia, but there are three distinguishing features not ordinarily noted in pneumonia: severe, localized, and persistent pain in the chest is a constant, almost invariable symptom. Sputum is scanty (or absent) and is not blood-streaked in the group of cases of cortical abscess. The physical signs may be indistinguishable from those of pneumonia and the röntgen film in the early stages may indicate only a pneumonic infiltration. Early flatness on percussion is the rule. This physical sign, however, in conjunction with the other features, should lead to the suspicion that the lesion is not a pneumonia but a cortical pulmonary abscess which has ruptured into the pleura. "Pneumonia" was the diagnosis for a week or longer in at least seven of our twenty-five cases. When foul sputum or foul odor on coughing exists the correct diagnosis is of course established. This conclusive evidence of putrid infection was present, however, in only eight of the cases. We report the following unoperated case (not included in our series) because it illustrates not only the clinical features and difficulty of diagnosis, but also the rapidly fatal outcome that is occasionally seen if operative relief is not given:

CASE REPORT.—A previously healthy middle-aged woman experienced sudden, severe, stabbing pain in the right posterior chest three days before hospital admission. The pain, which was aggravated by motion and deep breathing, was worse the next day but less on the third day. She felt feverish, had no cough and no expectoration. On admission there was dulness to flatness over the right lower chest and increased fremitus and bronchial breathing in this region. The diagnosis of lobar pneumonia was made. The physical signs did not change appreciably during the patient's stay in the hospital. Pain in the right chest was persistent. Fever ranged between 101° and 103°, pulse and respirations were not unduly accelerated at any time. There was occasional cough with expectoration of small amounts of mucus. The patient's progress appeared to be satisfactory

* To be reported by Dr. Leo Stern.

for the first nine or ten days. Euphoria and other evidences of toxæmia then developed, the general condition rapidly deteriorated, and death ensued two days later (twelve days after admission). At autopsy there was a large localized putrid empyema in the posterior part of the pleural cavity derived from the rupture of a small abscess in the posterior aspect of the upper lobe. A limited necrotizing pneumonitis existed about the site of the rupture. The other organs presented the usual changes associated with infection.

The course may at times be even more hyperacute and fulminating than in the above reported case. In our series there are a few instances in which patients were in a profoundly septic state within a week of the onset. On the other hand, well-defined encapsulation of a small putrid empyema may lead to a relatively mild and benign clinical course. We wish to repeat the point we deem important in this connection; namely, that a localized empyema, characterized by few symptoms for a week or longer, may then rupture into the general pleural cavity. The ominous event is marked by the picture of a most virulent infection. This sequence occurred in several of our cases and caused the death of one patient.

A detailed discussion of the cases with foul sputum and other symptoms of acute abscess of the lung would lead too far afield. In these cases the abscess of the lung was known to have been present for a varying period of time and rupture usually occurred under hospital observation. Such cases presented the characteristics of ordinary putrid abscess of the lung and not that of the cortical type above described. Their one distinguishing feature was the sudden cessation of expectoration of foul sputum when rupture took place. This phenomenon, together with the abrupt change in the patient's general condition and physical signs in the chest, usually led to prompt recognition of the pleural invasion. There are cases, however, in which it is difficult to distinguish by symptoms, signs, or röntgenogram, a large abscess of the lung from an encapsulated pyopneumothorax. The differentiation may be impossible at times even after the lesion is exposed at operation.

The röntgenogram of putrid empyema requires some discussion. The typical film of air and fluid in the pleura is seen only when there is a free bronchopleural communication. That the anaërobic organisms of putrid empyema are not gas-producing has already been pointed out. The amount of air in the pleura therefore depends on the degree of patency of the communicating bronchus. In not a few instances only irregular, insignificant accumulations of air are to be noted in films showing fluid in the pleural cavity. The diagnosis of empyema (not pyopneumothorax, of course) in its early stages is not made frequently from the film. The reason is that the picture may be identical with that of a massive pneumonic infiltration. We have no adequate explanation to offer for this fact and can only say that, on a number of occasions, a putrid empyema was found when the film was that of a pneumonic process.

For reasons that have been stated, displacement of the heart and mediastinum is rarely seen in the röntgenogram. The film may show multiple encapsulations of fluid or air and fluid, and the knowledge of the existence of two

or more pleural loculations is of course an invaluable guide in the operative treatment. In a few instances small circular areas of rarefaction within the lung fields appeared to prove the existence of multiple abscesses of the lung. In a case of putrid empyema resulting from a ruptured abscess of the lower lobe, the Röntgen film suggested an additional cortical abscess of the upper lobe. This was proven to be the case at a later operation.

The röntgenogram is not only essential in demonstrating fluid (with or without air) in the pleural cavity, but also in locating the site for exploratory aspiration and operative approach. Films should always be taken with patients in the upright posture. There were several unsatisfactory experiences resulting from incorrect localization at a time when complete reliance was placed on antero-posterior, postero-anterior and oblique films. We now regard the lateral film as an indispensable aid in correct localization of the pleural abscess or abscesses. It may also reveal a fluid level that cannot be seen in the postero-anterior films, particularly when the pocket is situated behind the cardiac shadow. Most important, however, is the fact that the lateral film may disclose an additional collection of fluid not suspected to exist from an inspection of the antero-posterior and postero-anterior films.

Diagnostic puncture is diagnostic only when the nature of the lesion is in doubt. The withdrawal of foul air is quite as pathognomonic as the withdrawal of foul pus. In not a few instances aspiration is performed to determine the site of operative approach rather than for purposes of diagnosis. The operative entry of the uninvolved pleura can readily convert an encapsulated putrid empyema into a virulent diffuse pleural infection. For the selection of the correct point of aspiration physical signs are of less value than a careful study of the Röntgen film. We do not minimize the value of physical examination and regard flatness on percussion as particularly useful in indicating the presence of pleural fluid. Unfortunately, however, physical signs are apt to be present over an area appreciably larger than the site of the collection of pus. They may point equally well to the presence of a "sympathetic" non-putrid collection of fluid about the empyema as to the essential lesion. There were several instances in our series in which the putrid empyema was overlooked for a time because aspiration revealed cloudy or purulent non-putrid fluid. There are no sites of predilection for putrid empyema since the underlying abscess of the lung may occupy any bronchopulmonary segment. The empyemata most difficult to disclose by aspiration are the infrapulmonary,[4] paramediastinal, and the rare interlobar varieties.

Operation after Positive Diagnostic Puncture.—When foul pus (or air) has been revealed by exploratory aspiration, operation should be performed without delay. The needle should be left in place whenever feasible, particularly in the cases of smaller empyemata and those not readily found by aspiration. Upon several occasions we have had considerable difficulty at operation in again locating the lesion after the needle had been withdrawn. There can be no question as to the necessity for immediate relief for profoundly toxic patients. There is a two-fold reason for prompt operation in patients who

are not seriously ill. The first is that nothing can be gained by delay, and, as already pointed out, general pleural invasion from an encapsulated empyema is always to be feared. The second is that a putrid phlegmon of the chest-wall may be the result of deferring operation after a positive aspiration. The insidiousness of onset and rapid evolution of this complication following the aspiration of a putrid empyema cannot be too strongly emphasized. In one case an extensive and virulent phlegmon of the thoracic parietes developed overnight. Putrid phlegmon of the chest-wall resulting from aspiration occurred four times in our series of fifty-one cases. Operation after positive aspiration was deferred in all four instances. The complication was serious in every case and, judging from the post-mortem examination, was the cause of death in at least two of the cases. We may add that putrid phlegmon of the chest-wall following aspiration of a putrid empyema is quite as serious as that after aspiration of an abscess of the lung.

Operative Technic.—Operation for putrid empyema is always indicated even if the patient appears to be mortally stricken. Several years ago one of the patients in our series seemed moribund at the time he came to operation. An apparently futile operation was performed, and a totally unexpected recovery followed. Subsequently we have had several similar experiences. Recovery in these profoundly prostrated patients appears to be due to the immediately favorable influence of evacuation and ventilation (aëration) on an anaërobic infection. Furthermore, the causative abscess of the lung having ruptured into the pleura, is no longer a factor making for mortality; the pleural infection remains the sole lesion for the body to combat. The essential principles of operative treatment are complete evacuation of the pus, adequate aëration and adequate care of residual lesions in the lung or pleura. Wide unroofing and visualization of the lesion are the steps by which these purposes are achieved. Full visualization is imperative to the end that no pockets remain. A sterile examining light for introduction into the cavity must be used for this purpose. Liberal excision of one or more ribs is performed, the tract of the aspirating needle being excised at the same time. The intercostal vessels are secured by hæmostatic sutures, regardless of whether or not they have been injured during the excision of a rib, because of the possibility of subsequent sloughing and hæmorrhage. The extent of costal excision depends on the size and shape of the encapsulated empyema, and should be just short of the limits of the lesion in order to avoid entry of the free pleura. In other words further removal of the same rib and (or) a section of an adjacent rib is often required after the primary entry into the empyema. When the general pleural cavity is the seat of a putrid empyema wide excision of one or more ribs (not complete unroofing) suffices. After the contents of an encapsulated empyema cavity have been evacuated by suction, recesses are inspected as leads to possible adjacent collections of pleural pus. If the latter are of appreciable extent, additional unroofing is performed. The operative wound may as a result have a bizarre shape because of cross-cuts, but this is more often the case in operations for putrid

empyema secondary to chronic abscess of the lung. The ruptured acute abscess of the lung causing the empyema is in the operative field when the empyema is encapsulated, but may be far away and quite inaccessible in generalized putrid empyema. The lesion in the lung should be visualized in most cases of encapsulated empyema for three reasons: first, as evidence that the empyema has been adequately unroofed. Second, in order that drainage will be maintained to the site of the bronchial fistula. Third, because the abscess of the lung may require better drainage than that obtained by the accident of rupture. The last point applies to the larger pulmonary abscesses and not to those of the cortical variety. Our earlier view was that the accident of rupture cured the abscess of the lung, but we since found that this only holds occasionally. It is true of the cortical abscess and of some of the larger abscesses if most of the roof has blown off. We know now that a small perforation of the ordinary type of abscess of the lung usually means persistence of the lesion unless the abscess is cared for. We have described elsewhere the operative treatment of the abscess of the lung. In brief, it consists in splitting open and excising the roof (beginning from the site of perforation in this instance), visualization of mouths of communicating bronchi, and packing the abscess cavity.

The operation for putrid empyema may be simple in some cases, may demand careful and deliberate execution in keeping with the pathological process, in others. The extent of the operative procedure cannot be foretold from the pre-operative study. The matter of drainage is secondary for us because of our conviction that by far the most essential step is the adequate operative treatment. Cure of anaërobic infection is based on the complete ventilation that can be assured only by a complete exposure. In encapsulated putrid empyema we pack all recesses with iodoform gauze in order to avoid premature coaptation of infected areas. The wound in the chest-wall is kept open with a loose iodoform gauze pack in which tubes are sometimes incorporated for ventilation of the depths. No deep drains or packings are used in generalized putrid empyema for they interfere with adequate ventilation of the extensively infected pleural surfaces. Reliance is placed on the large operative defect of the chest-wall. The margins of the wound are kept apart with a loose gauze pack in which wide-mouthed tubes are incorporated.

The Post-operative State.—The test of the adequacy of operative treatment is the post-operative condition of the patient and the condition of the wound. There are few more dramatic changes to be seen in surgery than those which occur in the condition of a patient suffering from putrid empyema after an adequate operation has been performed. If a markedly toxic state had existed it is usually gone within twelve to twenty-four hours. Pain, dyspnœa, rapid cardiac action and fever quickly abate. Cough and the expectoration of foul pus if present before operation cease abruptly. We have seen this extraordinarily rapid alteration occur even when patients appeared to have been overwhelmed by infection and mechanical distress at the time

of operation. The other test of adequacy of operative treatment is to be noted in the operative field. There should be no foul odor or foul discharge, and the wound should have a healthy appearance within a few days. Under these circumstances packings in recesses can be left undisturbed for a week or longer with the expectation of encountering clean surfaces throughout the empyema cavity upon their removal. Recesses are maintained by packings until there is no likelihood of the shutting-off of residual infection that may still be present. The most important aspect of post-operative treatment is concerned with the bronchial fistula. We have said that a bronchial fistula will almost invariably be noted after operation even if it was not visualized at operation. The fistula must be maintained by means of a packing placed against it or at a later time by a tube leading to it. All the symptoms of a putrid abscess of the lung may ensue upon premature closure of the fistula. Apparently pathogenic anaërobes remain viable in the wall of the abscess of the lung after they have disappeared from the surfaces of the empyema cavity. The maintenance of the fistula proved to be less imperative when the abscess was of the small cortical variety, but even then there were instances in which its early closure was followed by the manifestations of lung abscess. We do not regard the fistula following rupture of an acute abscess as a problem. Our difficulty has been rather with the maintenance of the fistula, for there is a very marked tendency towards early closure. Spontaneous healing occurred in all our cases when the tube or packing was discontinued. The criteria upon which we base the time for discontinuance of the fistula are similar to those after operation for abscess of the lung; namely, absence of symptoms, absence of pulmonary infiltration in the röntgenogram, and negative bronchoscopy.

Although fewer problems have arisen in post-operative treatment as experience gradually clarified our views, we do not wish to give the impression that the course is always as smooth after adequate operation as described in the previous paragraph. The statements which were made apply to typical cases and, in particular, to the cases of ruptured cortical abscess of the lung. Some empyemas, such as those situated paramediastinally or beneath the lower lobe, require considerable attention after operation and close scrutiny for encapsulations beyond the operative field. Secondary operations for additional pockets were necessary in several cases. The chief problem, however, is the underlying lung abscess. If the patient is not doing well and the empyema has been adequately cared for, the abscess of the lung can be assumed to be the cause. No doubt remains if foul expectoration is present after operation. Repeated Röntgen-ray examinations and bronchoscopy may have to be resorted to before the abscess of the lung can be shown to exist and its site identified. The difficulties in diagnosis and treatment that may be encountered are illustrated by the following case:

Case Report.—A boy of fifteen, who had no related antecedent illness, came under observation with a history of right lower lobe "pneumonia." The onset was sudden with a chill and fever rising to 104°, severe pain in the right lower chest and cough. Fever

was sustained and pain persistent. Cough was productive of small amounts of odorless sputum, slightly blood-streaked. The physical signs were soon those of a rapidly developing pleural effusion. On the eleventh day of illness the chest was aspirated and, to the surprise of the attending physician, foul pus was withdrawn. A röntgenogram was immediately taken. It revealed a large pyopneumothorax. The collapsed lung was seen to contain an oval cavity about an inch in diameter, in the upper lobe. Operation was performed the same day. The large putrid pyopneumothorax was evacuated through a paravertebral approach, sections of the fifth and sixth ribs being excised. The cavity was inspected with a sterile light. In the midst of gangrenous exudate covering the lung the perforated abscess was noted. Directly above the fistula an elevation of the surface of the lung was seen. It was aspirated, foul pus obtained, and a crucial incision was made. Whether this abscess of the lung was part of the abscess that had ruptured or was a separate lesion could not be determined. The abscess of the lung and the empyema cavity were packed.

Although fever gradually reached lower levels it did not subside after operation. Cough was persistent and the sputum was frankly foul in odor on several occasions. The röntgenogram disclosed the fact that the cavity noted in the original film persisted. Accordingly, a second operation was performed. The abscess was sought for by aspiration in the upper part of the empyema cavity. Infiltrated lung which bled freely was encountered. There was a sudden ominous change in the patient's condition, the pulse becoming poor, respirations shallow, and deep unconsciousness developing. A cerebral embolism derived from hæmorrhage at the site of aspiration of the lung was assumed to be the cause of these manifestations. In view of the fact that the abscess had not been found by the aspirating needle an aseptic (or relatively aseptic) embolus was postulated. Further search for the abscess therefore seemed warranted. The abscess of the lung was found by the aspirating needle and treated in the customary manner.

A right-sided hemiparesis was noted after operation. Coma was replaced by a delirium which gradually subsided. Aphasia and a right homonymous hemianopsia were soon apparent. Cough and expectoration ceased shortly after operation and did not recur. Fever disappeared within ten days. The neurological manifestations of the cerebral accident slowly receded. They were no longer present four months after operation with the exception of slight defects in the visual fields. At that time the bronchial fistulæ were healed and the Röntgen film indicated the absence of pulmonary infiltration.

Interlobar putrid empyema is a fortunately rare variety of putrid empyema, to which no reference has as yet been made. There is no variation in operative treatment when there are widespread adhesions to the parietal pleura. The solution of the problem of drainage of an empyema locked between two lobes without the presence of parietal adhesions lies in a two-stage operation. The aspirating needle that revealed pus has already traversed the free pleura and there is no warranty for additional contamination. The first realization of the true nature of the lesion will probably be gained at operation and only then if the pleural cavity is widely opened. The aspirating needle may have penetrated the lung to reach the empyema. There is a close resemblance between an interlobar empyema and an unruptured abscess of the lung facing the interlobar fissure, but the treatment is almost identical. The lesion is widely isolated by packings and the next stage is postponed until the free pleural cavity has been completely sealed off. At the second stage the two lobes are bluntly separated to enter the empyema. If this is not possible the thinnest portion of the overlying shell of lung is traversed by sharp dissection. In either event the subsequent procedures are

carried out in the usual manner. The sequel of the only one-stage drainage of an interlobar putrid empyema in our series was a widespread and almost fatal infection of the general pleural cavity.

The application of other forms of surgical treatment of empyema to putrid empyema has been considered only in connection with the usual operations for empyema as compared with the type of operation which we have detailed. Regardless of the views which may be held on the Potain treatment of other varieties of empyema, it can have no place in the treatment of the putrid variety because of the danger of phlegmon of the chest-wall. This complication is always ominous and was the cause of death in one of our cases. Closed drainage can be justified as a treatment for putrid empyema only because of the danger of open operation in the presence of a mobile mediastinum. We have pointed out, however, that the mediastinum is to be regarded as adequately steadied by visceroparietal adhesions in almost every case. A basic objection to closed drainage is its inability to deal adequately with and to eradicate the anaërobic infection because free ventilation is not offered. That addition of air is not free ventilation as proven by the fact that air naturally present in a putrid empyema (putrid pyopneumothorax) does not influence the lesion favorably as far as we know. It must be borne in mind that most patients suffering from putrid empyema are seriously ill and some are desperately sick. For such patients possible palliative measures have no place when definitive methods are at hand. Our experience with closed drainage is limited to three cases. In a recent and unusually mild case the method was effective, a later excision of a rib for better drainage being performed. Closed drainage was entirely without effect in two severe cases of putrid empyema. About twelve hours had elapsed in one of these between the time of closed drainage and open operation. The general condition became obviously worse in that short interval despite the drainage of a considerable amount of foul pus. A phlegmon of the chest-wall about the site of drainage was already present at the time of open operation.

The results of operation in the twenty-five cases of putrid empyema secondary to ruptured acute abscess of the lung can be briefly stated. There were two deaths. That the cause of death in each case was avoidable should be especially noted. In one the patient was known to have had an encapsulated putrid empyema for at least a week. Rupture then occurred, and death followed operation for the putrid infection which had diffused throughout the pleural cavity. In the other case Potain treatment was employed. Operation was performed for the widespread putrid phlegmon of the chest-wall and the putrid empyema which persisted. A short analysis of the twenty-three cases that survived will suffice. All are well, and healed with two exceptions. There are recent cases in which the bronchial fistulæ are still maintained by tubes. Four cases required operation at a later date for the causative abscess of the lung. It is of interest to note that these were cases of diffuse empyema and that the abscess of the lung was situated at a considerable distance from the site of drainage of the empyema in three of the four

cases. In one of these the diffuse infection was drained through a posterolateral incision. The abscess of the lung was subsequently localized below the clavicle and operated upon in that region. Considering the group of ruptured acute abscess of the lung cases as a whole, sufficient evidence has been advanced to justify the statement that there should be little or no mortality from putrid empyema or its causative acute abscess of the lung. An appreciable mortality can be ascribable only to procrastination or to so-called conservative surgical measures, for the lesion is extraordinarily responsive to adequate operative treatment.

RUPTURED CHRONIC ABSCESS OF THE LUNG

Arguments have been advanced elsewhere[2] in favor of operation for putrid abscess of the lung before it reaches a chronic stage. It has been shown that many cases of acute abscess of the lung that appear to recover spontaneously pass more or less insidiously into a chronic phase. The relative simplicity of operation for acute abscess of the lung and the good results which followed early operative treatment were pointed out. By way of contrast, the difficulties in operation and the untoward complications and sequelæ were stressed in the case of chronic abscess of the lung. The strength of these arguments is evident in an analysis of the sixteen cases of putrid empyema which complicated chronic abscess of the lung. There were eight recoveries and eight deaths. The fate of the patients who recovered after operation for putrid empyema is significant. There was improvement in the symptoms of abscess of the lung in one case. Two were subsequently operated upon for chronic abscess of the lung and are well. In the remaining five the extensive chronic lesion with its accompanying bronchiectasis (or latticed lung) remains, and the outlook for these cases is bad. The eight fatal cases died at varying periods after operation. Death can be ascribed to the complicating empyema only in two cases in which the pleural infection was diffuse and developed after prolonged chronic pulmonary suppuration. Autopsies demonstrated that progressive extension of the abscess of the lung was the cause of death in four cases, weeks to months after empyemata had been drained. The remaining two cases died of cerebral and other metastases.

The picture of high mortality and untoward sequelæ having been presented, we would now note that putrid empyema is a much more insidious complication of chronic than of acute abscess of the lung. It is sometimes only a terminal phenomenon, as in the two cases that were mentioned. Indeed, there are a number of instances among unoperated cases not included in this series in which putrid empyemata complicating chronic abscess of the lung and not suspected during life were found at autopsy. The insidious variety apparently resulting from slow perforation is thus one that may offer great difficulties in diagnosis. In several cases pleural infection was not suspected, but was encountered at operation; in other cases the diagnosis of empyema was made but was found to be incorrect. The symptomatology of the chronic abscess of the lung is not often appreciably altered by the develop-

ment of this insidious form of empyema. The amount of sputum may diminish coincidentally with the onset of pain in the chest over the site of the abscess of the lung. Some fulness of the chest-wall in that region may be discernible. Localized tenderness and a sense of resistance are noticed in some cases. The percussion note is apt to have a peculiar flat and wooden quality, and the other physical signs become more extensive than theretofore. Only in a very few instances were the characteristic auscultatory phenomena of fluid and air in the chest observed. Since the insidious form of perforation usually results in a localized pyopneumothorax, the diagnosis can be suggested by the röntgenogram. The film of air surmounting a fluid level is not pathognomonic unless the lateral film demonstrates that no pulmonary tissue intervenes between the collection and the chest-wall. If free mobility of the fluid with change of position is noted at fluoroscopical examination, the diagnosis of pyopneumothorax is established. Evidence of an intense pleural reaction seen in the röntgenogram, especially when compared with previous films in which it was not present, is also indicative of pleural penetration. There were a few cases in our series in which iodized oil introduced for bronchography as part of our routine study of all cases of chronic abscess of the lung, was found to enter a periphery cavity. Since we have demonstrated that the oil rarely if ever enters the cavity of an abscess of the lung (unless on a tuberculous basis) the demonstration of a cavity (not a dilated bronchus) in the bronchogram accidentally proved the existence of perforated abscess of the lung in these cases. Among our cases were two in which the empyema had remained unrecognized over a long period of time despite unmistakable symptoms. These patients described an inability to lie on the unaffected side without spasms of coughing, and intermittent expectoration of enormous quantities of foul pus.

The general remarks which we have made on the subject of exploratory aspiration apply with equal force to aspiration in cases of encapsulated pyopneumothorax secondary to chronic abscess of the lung. Some additional comments should be made. The intercostal spaces may be narrowed, and entry into the cavity may be difficult because of the presence of a thick and resistant parietal membrane. The difficulties are increased when the empyema is small and atypically situated. An important fact to be borne in mind is the elevation of the diaphragm which so often accompanies a chronic abscess in the lower lobe. There were two cases in our series in which inadvertent penetration of the diaphragm by the aspirating needle was followed by putrid subphrenic abscess.

The diagnostic criteria of perforation of a chronic abscess of the lung, a localized empyema, or a secondary bronchiectasis into the free pleural cavity are identical with those of perforation of an acute abscess. The only difference is that the abscess of the lung was known to have existed and its situation may have been determined. The expectoration of foul pus ceases abruptly or is greatly reduced. The sudden untoward change in the patient's general

condition, severe pain in the chest, respiratory embarrassment, and rapidly developing toxæmia, are the cardinal manifestations.

The operative treatment of empyema complicating chronic abscess of the lung also presents no essential differences. The principles are the same as those described under perforated acute abscess of the lung and will not be repeated. The treatment for perforation into the free pleural cavity is identical. Operation for the encapsulated form, however, often presents more difficulties than the same operation in cases of ruptured acute abscess of the lung. The operative entry into the cavity may be truly laborious because of the density and thickness of the parietal membrane and the peripleural tissues. If the pyopneumothorax is small it can be surprisingly elusive in this dissection. The unroofing of the cavity is tedious. Hæmorrhage is usually brisk from vessels whose orifices are held open by fibrous tissue and many hæmostatic sutures may have to be placed for its control. The greatest difficulty, however, lies in the unroofing of the various ramifications of the empyema. All recesses must be thoroughly investigated because one or more of them may lead via narrow channels to encapsulations distant from the primary cavity. Of course these problems are not present in all cases, but an adequate operation is often a prolonged procedure and one of considerable magnitude. As in all operations for abscess of the lung, we now operate on the patient with empyema complicating chronic abscess of the lung in the Trendelenberg position in the hope of minimizing the ascent to the brain of infected clot aspirated into branches of pulmonary veins. A slow intravenous drip (begun before operation) is continued throughout operation, and is maintained for varying periods of time thereafter.

PUTRID EMPYEMA AFTER OPERATIONS FOR ABSCESS OF THE LUNG

As the result of post-mortem examinations on patients who died after operations for abscess of the lung, we have learned that the most important causes of death are gangrenous spillover infections of fresh areas in the lung and putrid empyema. It is significant that the empyemata were not proven during life in five of the ten cases in our series. They were suspected in most of the cases on the laws of probability rather than on the basis of clinical or röntgenographical evidence.

The same statement holds for the five cases in which the diagnosis of putrid empyema was made during life, and the lesion operated upon. We have learned that, after an adequate operation for lung abscess, an unsatisfactory course characterized by high fever and other evidences of toxæmia, indicates either spillover infection, putrid empyema or both. The early postoperative röntgenogram is usually not entirely informative and, in addition, the patient is usually in such poor condition as to be unable to coöperate in obtaining a good film. The physical signs of fluid in the pleural space are not distinctive after operation, and with the exception of dulness or flatness on percussion are apt to be confusing. The physical signs on the opposite side may be definitely those of a pneumonic infiltration and hence ascribable to a spill-

over infection. At the same time a putrid empyema may be present on the operated side. It is therefore safer to assume that the cause of the patient's unsatisfactory post-operative state is a putrid empyema, and a persistent search should be made for this complication. Many aspirations in different parts of the chest may be necessary before the empyema is disclosed. In one of our cases the search was pursued for nine days before the putrid empyema was discovered. The collection of foul pus may be situated at a relatively inaccessible site, such as the paravertebral gutter. It may be encircled by cloudy or purulent odorless fluid and, under these circumstances, the diagnosis of a bland pleural infection may be made. "Sympathetic" effusions, however, do not account for the clinical state to which we refer, and their presence should lead to redoubled efforts to disclose by exploratory aspiration an underlying putrid empyema. Finally it must be added that there were a few cases (not belonging to this series) in which the post-operative pleural infection was a pneumococcic or staphylococcic pleuritis and not a putrid lesion. Why a putrid empyema did not develop in these cases is not known. The clinical course was comparatively benign, with a single exception.

Autopsy Reports.—A brief recital of the five cases of abscess of the lung in which the empyema was found only at autopsy, is warranted. The first was a trilocular subacute or subchronic abscess. The last of three abscesses that were entered was the most superficial and most recent, and the overlying shell of lung was thin and covered by some pleural exudate. The free pleural cavity was not entered. The post-operative course was fulminating and death ensued in four days. The post-mortem examination disclosed a diffuse putrid empyema derived from the last abscess that had been opened. In the second case an operation for an abscess of the lung and adjacent mediastinum had been performed. A post-operative putrid empyema was diagnosed and drained. Death was due to an additional empyema, distant from the operative field, which was not suspected during life. The third case was similar to the first. At the operation for a subacute abscess adequate visceroparietal pleural adhesions were traversed and the free pleural cavity was not entered. The autopsy revealed a putrid empyema due to spread of infection from the region of the drained abscess and not to an open communication with the free pleural cavity. The two remaining cases can be grouped together. The free pleural cavity was not entered at operation in either case. Autopsies demonstrated empyemata, distant from the operative field, derived from gangrenous spillover abscesses of the lung which ruptured into the pleura.

It is therefore evident that a post-operative putrid infection of the pleura may occur in the region of a drained abscess even though the free pleural cavity has not been entered, or can be the result of a spillover infection of some other previously uninvolved portion of the lung. When the free pleural cavity has been opened at any stage of an operation for abscess of the lung, the mechanism of post-operative empyema related to the operative field is of course clear. Under these circumstances the mortality of the complication was four deaths in five cases in which the putrid empyema was diagnosed and operated upon. The deaths can be ascribed, in part at least, to the delay in suspecting, discovering, and therefore operating upon the lesion. They may be ascribable in part to the operative procedure, because closed drainage was employed in two of the cases. In these instances (which occurred in an

earlier phase of our work) the patients appeared to be too ill to withstand open thoracotomy. We now know that a liberal opening might have been followed by recovery. That one of these cases developed a putrid phlegmon of the chest-wall is of interest in connection with what has already been said on the subject of closed drainage.

A post-operative complication that is fatal or contributes to fatality in nine out of ten cases is truly to be feared. The difficulties in recognition and treatment have been indicated. What can be done prophylactically? Gross soiling of the free pleural cavity by a one-stage operation for lung abscess in the absence of adhesions is too obviously avoidable to require discussion. We have shown elsewhere that pleural adhesions are always present over an abscess of the lung and can always be encountered if sought for at the correct site. The question that comes up in some cases is not whether they exist, but whether they are sufficiently widespread and firm to permit of the performance of a one-stage operation on the abscess. If any doubt exists, entry of the abscess should be deferred. The desirability of a one-stage operation requires no emphasis, but the risk of fatal pleural infection should not be incurred. The free pleural space may be opened at operations for abscess of the lung even when carried out in the presence of adequate adhesions. The entry may be inadvertent at the time of costal excision, or when the wound is enlarged for wider unroofing of a multilocular abscess. Coughing or straining by the patient may be the cause. A small opening is of as ominous significance as one of large size. If the opening occurs before the abscess has been aspirated or otherwise entered, a two-stage operation should be performed unless the free pleural cavity can be thoroughly shut off. An important decision is that of the proper procedure to be employed if the free pleural cavity is opened after the abscess has been entered. Under such circumstances we do not depend on packings placed to or into the opening but prefer to broadly suture the normal lung to the soft parts of the wound whenever feasible. The site is carefully examined in order to be assured that no minute pleural communication exists before proceeding with the operation. Others may hold that further operative procedures should be deferred once the free pleural cavity has been opened. Our reason for completing the operation is based on the desirability of reducing or eliminating post-operative coughing as well as the putrid infection. The strain of coughing may reopen the pleural rent no matter how securely it has been closed and the undrained abscess may contaminate the reopened pleura. We know of instances in which this has occurred.

An essential prophylactic step, in our opinion, is the drainage of the free pleural cavity if opened during the operation on the abscess of the lung. Under such circumstances we have for some time employed closed drainage. The fact that all the cases of post-operative putrid empyema following operative entry of the free pleura occurred only during our earlier experience, seems to prove the efficacy of prophylactic drainage of the free pleura. Closed drainage apparently meets the requirements, for we have no recent cases to

report. An empyema does not, of course, develop in every instance in which the free pleural cavity has been contaminated. Our cases of prophylactic closed drainage are as yet too few for definite conclusions to be drawn.

The group of five cases in which there was no communication with the free pleural cavity warrants some therapeutic consideration. As already stated, the empyema was discovered only at post-mortem examination. The facts, as noted in two of the cases, establish the necessity of going farther than the diagnosis of a spillover infection of the lung. The latter is often sufficiently extensive to lead to death. But the evidence also indicates the necessity of considering the possibility of a putrid empyema as an early complication of a spillover infection which may be of limited extent. Prompt operative treatment of the empyema may result in recovery. The two instances in which putrid empyema developed in the region of the abscess of the lung (although the free pleural cavity was not entered at operation) were in cases of abscesses situated very superficially in the lung. The pre-operative clinical course was severe and progressive in both, suggesting that a virulent infection existed. As a result of the study of these cases, we have come to the conclusion that a pre-perforative stage of abscess of the lung can and should be recognized at the time of operation, and that prophylactic closed drainage of the pleural cavity should be performed under such circumstances even though it is not entered at operation.

SUMMARY

Putrid empyema should not be classed with other forms of empyema.

It is a definite entity. The lesion results from the rupture of a putrid abscess of the lung.

The pathology, symptoms, and diagnostic criteria are detailed.

An understanding of the features of putrid empyema is essential for effective treatment.

The importance of differentiation between putrid empyema and pneumonia with early pleural effusion is emphasized.

The risks in deferring operation, particularly after positive diagnostic aspiration, are stressed.

An operation termed "complete unroofing" for the purposes of complete drainage and ventilation is advocated for encapsulated putrid empyema.

Wide drainage (ventilation) is described as the operation for diffuse putrid empyema.

The empyema derived from an acute abscess of the lung is extraordinarily responsive to adequate operative treatment. An appreciable mortality can be ascribable only to procrastination or to so-called conservative surgical measures.

High mortality and untoward sequelæ characterize the results of operation for empyema secondary to chronic abscess of the lung. Knowledge of these facts should lead to operative treatment of abscess of the lung before the chronic stage is reached.

Putrid empyema following operation for pulmonary abscess is a very fatal complication. Prophylactic measures are advocated.

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DIVERTICULA OF THE SMALL BOWEL

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The enormous advances in röntgenological technic within the past fifteen years have brought to our attention the relative frequency with which there occur in the gastro-intestinal tract certain abnormal outpouchings or pockets which, in the majority of instances, give rise to few symptoms of importance, although occasionally complications arise from them which are of the gravest significance. These diverticula, occurring as they do throughout the entire gastro-intestinal tract, are quite commonly found associated with inflammatory changes and complications when situated in the colon, but single or multiple diverticula of the small bowel are encountered (Figs. 1 and 2) which may or may not give rise to any symptoms. Whether or not the diverticula throughout the entire gastro-intestinal tract are etiologically identical is a moot question. Certainly there are two varieties, the acquired and congenital, the latter undoubtedly representing the same factors, whether it be situated in the upper or lower gastro-intestinal tract.

The difference between the true and the acquired diverticula consists in the number of coats of the intestinal wall which covers each. If the entire intestinal wall thickness makes up the outpouching, it is designated as a true, and if one or more coats are absent, as a false diverticulum. The congenital variety is most accurately represented by the so-called Meckel's diverticulum, a vestigial pouch situated in the lower ileum which is found in a great many individuals coming to operation or autopsy. Advances in Röntgen diagnosis are now calling attention to the large numbers of these diverticula found higher up, particularly in the duodenum. Case, in 1912, made the first Röntgen diagnosis of diverticula of the small bowel and since then this condition has been amply reported in the literature.

Etiology.—The factors which govern the production of diverticula are not all clear, nor is it certain whether the majority of them are of the congenital or the acquired type. The pulsion or traction diverticula with which we commonly associate these lesions in the œsophagus or colon represent a group of the small intestinal ones as well. Morrison, in his discussion on diverticulitis, makes a clear distinction between the true, congenital diverticula and the acquired type which he calls a sacculation. His feeling is that there is the same difference between a sacculus and diverticulum as there is between a congenital and acquired hernia. It seems logical, also, to assume that at some stage of their development, all false diverticula were covered by all the coats

of the bowel wall and, hence, might be included in the classification of the true type, the growth of the pouch causing the circular muscle to atrophy or to slide off the side and recede to the base of the diverticulum.

Another interesting fact, which is likewise speculative, is the time of life at which symptoms arise from diverticula. The majority of patients have symptoms only in middle or advanced age, a fact that has led certain observers, among them Jordan and Lahey, to assume that the acquired type was originally due to congenital anatomical or pathological weakness. Drummond believes they are due to congenital weakness of the non-striated muscle tissue, the assumption being based on the fact that out of twenty-two specimens found in the large bowel in a series of 500 necropsies, five had diverticula elsewhere—four in the small intestine and one in the bladder.

FIG. 1.—Large single diverticulum of the first portion of the duodenum.

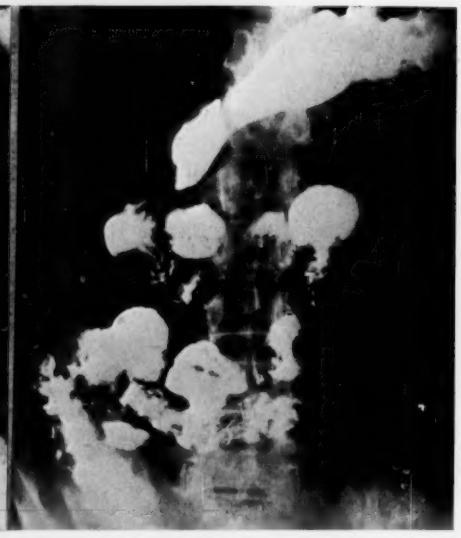

FIG. 2.—Multiple diverticula of the jejunum. One large diverticulum shows in the duodenum.

The association of diverticula throughout the gastro-intestinal tract, and indeed, in other portions of the body, is not an unknown one. The relationship of the diverticula to the blood-vessels has been called to attention by Klebs and others, who noticed a tendency of the diverticula to occur on the mesenteric border, an observation which apparently supported the theory of anatomical weakness. Our observation has been that while some of the diverticula occur where blood-vessels enter the intestinal wall, the majority of them are opposite the mesenteric border, or on the lateral wall of the bowel at some distance from the blood-vessel. This observation is not ours alone but is concurred in by McConnell and others.

Halvestine believes that traction by sclerosed vessels plays a part in diverticula formation and that intra-abdominal pressure, due to straining at stool or emptying the bladder or severe coughing, causes sufficient force to initiate their development. This type of pressure is intermittent and obviously reaches a maximum suddenly. Such pres-

sure on a full section of intestine would be much more efficient in causing a protrusion of the wall at a weakened point than a gradual increase in intraluminary pressure consequent to accumulation of gas or fecal material. In the case of the small intestine, where the contents are liquid and are easily forced through a small opening, such as the pylorus or ileocæcal valve, the fluids would readily follow the line of least resistance and flow through one of these portals and, consequently, it does not seem feasible to believe that the pressure in the small intestine could be raised sufficiently by coughing or straining to produce diverticula, unless there were some obstruction to the regurgitation into the stomach or expulsion of the fecal current.

Hausemann, in 1896, claimed that increased intra-abdominal pressure, caused by accumulation of gas or fæces, might be the cause of intestinal diverticula, and undertook to prove this and the fact that they occurred on the mesenteric border, due to their following the blood-vessels, by filling sections of the intestines taken from cadavers, with water under pressure. Chlumsky repeated these experiments, using the intestines of living dogs, and found, contrary to the experience of others, that the diverticula always occurred on the anti-mesenteric border, which was the weakest spot.

The two types of experiments, one in the living bowel and the other in the cadaveric section, are not comparable. Beer, in 1904, experimenting on colonic diverticulitis, refuted many of the hypotheses advanced as to the production of diverticula and the relationship of constipation, venous stasis, and so forth, to their formation. He forcefully brought out the fact that the supposed weakness at the mesenteric border does not exist and therefore cannot account for the production of all diverticula. He stated, however, that there was some change in the resistance of the bowel wall and that there was consequent muscular deficiency, which probably accounts for the formation of false diverticula. His explanation must be looked upon favorably because it will explain the presence of diverticula in both the mesenteric and the antimesenteric portions of the bowel. Also, this belief would suggest that diverticula will develop where the muscular weakness is localized to a small area of muscular tissue; the mucosa would be pushed along the lines of least resistance, the weakened muscle bundles parting, and the direction of the sacculation would be the course of least resistance on the mesenteric sides along the veins.

We have felt that there was no one factor which produces diverticula but that the outstanding features of their formation have to do with inherent weakness of the wall of the bowel in addition to increased intracolonic (or intra-intestinal) pressure. Undoubtedly, predisposing factors are congenital weaknesses, obesity, venous stasis, and constipation.

Symptoms.—It has not been shown that diverticula of the small bowel show any definite syndrome. In fact, the majority of our cases gave no symptoms referable to the gastro-intestinal tract, and it has been impossible, in reviewing the literature, to arrive at any definite chain of evidence.

In 1906, Gordinier and Sampson advanced the opinion that it was not known just what rôle small bowel diverticula played in the causation of minor complaints, such as indigestion and indefinite abdominal pain and discomfort. Their case showed no symptoms until diverticulitis had appeared with infiltration of the mesentery, localized peritonitis and adhesions between the mesentery of the small intestine and the transverse colon, kinking the colon with a resultant partial obstruction.

MacKechnie, in discussing symptoms, states that it is a well-known fact that, next to the contents of the duodenum, those of the jejunum are the most toxic of the gastro-intestinal tract. The broken-up foodstuffs are quite toxic, and, if they are delayed in their passage, an undue amount of toxins gain entrance to the circulation and give rise to gastro-intestinal disturbances, with indigestion, mild and prolonged, alternating constipa-

tion and diarrhœa, bilious attacks, which should be designated as toxic attacks, anorexia, nausea and vomiting, pain, mild but persisting, and more or less indefinitely located.

Spriggs and Marxer, who found 143 patients with diverticula of the large and small bowel, in the course of 1,000 consecutive gastro-intestinal X-ray studies, fourteen of which were in the small bowel, judged that eighteen of these complained of symptoms due to the diverticula but did not differentiate between those of the large and small bowels. They concluded that the symptoms were probably due mainly to stretching of the pouch by distention with food, or irritation by either acid or putrefying material.

Drueck believes that definite symptoms are absent in almost 50 per cent. of the cases as is indicated by the frequency with which diverticula are incidental findings at autopsy, röntgenographical examination or surgical exploration.

Jordan and Lahey state that symptoms may arise from pressure of a filled sac on the tube itself, or upon adjacent structures, from retention of the contents with irritation and inflammation. They assume that except in the œsophageal portion of the tract it is difficult to ascribe symptoms solely to the presence of diverticula.

Case summed up the symptoms as mild and prolonged indigestion, bilious attacks more accurately described as attacks of auto-intoxication, characterized by loss of appetite, nausea and vomiting, coated tongue, abdominal distention, mild but persisting indefinite pain, muddy complexion and general debility. Two of his cases vomited blood; one copiously. Constipation, he states, increasingly resistant to treatment, sometimes alternating with diarrhœa, has been a prominent symptom. Acute intestinal obstruction brought several to the operating or post-mortem table.

Hurt and Cook reported their case to have a rather definite onset with rapid and considerable loss of weight, pain and discomfort of rather uncertain character, but in general corresponding to the period when the sac might be distended by partially digested food, and radiating to the upper lumbar region with diffuse and inconstant tenderness in the region of the sac.

Stelton's patient complained of severe abdominal pain, vaguely referred to the upper abdomen, accompanied by gastric distress and nausea lasting several hours. The abdomen was sensitive to pressure during the attack, but there was no definite point of tenderness.

Baastrup's patient complained of pain in the abdomen, particularly on the left side, lasting a few hours and having fever with the attacks. There was no vomiting.

Terry and Mugler reported a case with symptoms of duodenal ulcer. No diverticula were demonstrated at X-ray. At operation a duodenal ulcer was found and five diverticula were found in the jejunum. The two largest ones were inverted. Eighteen months later the patient developed acute intestinal obstruction and operation showed that an enterolith had formed in one of the diverticula, filling the lumen of the upper jejunum. This was broken up.

Pinniger and Burman report a case who developed an acute obstruction. At exploration nothing was found except multiple diverticula on the mesenteric border. Nothing was done. Four days later he became obstructed again and promptly died. Post-mortem examination revealed multiple diverticula.

Christie's case was a woman, aged forty-eight years, who had suffered for years with flatulence and recurrent attacks of colicky pain. She was seized with an acute abdominal pain. A mass was felt just below the umbilicus. She was put on medical treatment for fourteen days. Operation revealed a perforated diverticulum in the jejunum on the antimesenteric border, enveloped by omentum. He did an excision and inversion with a lateral entero-enterostomy.

Braithwaite reports a rather unusual case of a man, aged fifty-four years, who was found to have diverticula of the jejunum by X-ray and was thought to be suffering from chronic obstruction. Five years later he returned on account of pain and nausea after food. He stated that he had had dyspepsia as long as he could remember. When he was

eighteen years old he had dislocated his knee. Beginning one year after that he had had periodic attacks of indigestion, flatulence, pain and vomiting. Very frequently the attacks were accompanied by synovitis of the injured knee. For ten years he was free of synovitis and had had very little indigestion during that time; in fact, he had enjoyed very good health. During the air raids of the war, indigestion had returned and in due course the synovitis followed. He stated that one hour after meals he had a "swelling of the body" and much flatulence. Once he had a severe attack and vomited five pints of blood. At operation, many diverticula of the jejunum were found, the first one at the duodenojejunal flexure. The upper few feet of the bowel were hypertrophied and dilated. Owing to the pressure of the diverticula at the flexure, excision was inadvisable. Lateral anastomosis was done below the diverticula. The result of the first operation was nothing. At a second operation resection was done below the first diverticulum, the first one being inverted. Recovery was good and three months later the patient reported that he was free from symptoms.

Watson reports a case of a man aged seventy-three years who complained of pain in the abdomen with increasing constipation. A movable tumor was felt a little to the right and below the umbilicus. At operation he found a tumor, between the layers of the mesentery of the jejunum, causing incomplete obstruction by traction and encroachment on the lumen of the bowel. He thought it was malignant and resected eight inches of the bowel. Section showed it to be an enterolith in a diverticulum.

Balfour reported a case of a man aged sixty-two years who gave a twenty-year history of gastric distress, suggesting duodenal ulcer, with epigastric pain about one hour after meals and continuing until the next meal when pain was relieved. At operation an anterior duodenal ulcer was found with many adhesions between the mesocolon and the jejunal mesentery, necessitating an anterior gastro-enterostomy. There were four diverticula present; three were sixteen inches from the duodenojejunal junction and one was four inches. All were on the mesenteric border and were thought not to be causing symptoms and hence were not disturbed. The anastomosis was made distal to the diverticula.

Haltung reported a case of a woman sixty-six years old who gave a history of black, tarry stools.

Simons reported a case of a man aged fifty-seven years who was seized with excruciating pain, constant in the upper abdomen and with slight nausea. There was no history of trauma. He complained of no bowel trouble. He gave a history of having had three attacks of typhoid fever before he was twenty years of age. Twice, approximately eighteen and twenty years previously, he had had similar though milder attacks. Physical examination showed board-like rigidity of the upper abdomen with tenderness in the mid-epigastrium. He was diagnosed as ruptured duodenal ulcer. Exploration showed the stomach to be normal, the small bowel to be distended and cyanotic. No pulsations of the mesenteric artery were felt. The mesenteric veins were engorged. The discoloration extended down three feet; two feet of the mesentery were milky-white in color. There was a sharp line of demarcation between the white and the healthy mesentery. The bowel, from the healthy mesentery up, had innumerable diverticula extending between the layers of the mesentery. The intestine was stimulated with hot packs and the abdomen closed. He concluded that the symptoms were due to a rupture of the lymphatics with extravasation into the mesentery. Recovery was due, he believed, to absorption of the exudate, and the release of pressure on the vessels prevented actual gangrene.

Boling's case was a man aged fifty-eight years who was operated on for obstruction and multiple diverticula of the jejunum were found. An enterostomy was done. Ten months later he had generalized abdominal pain, nausea and vomiting. Enemas gave fair relief and the patient was apparently all right for thirty-six hours. He again became distended and had rigidity and tenderness. Enemas gave no results. He was operated on and a resection done, removing 153 centimetres from 30.5 centimetres below the liga-

ment of Trietz. An end-to-end anastomosis was done. Fifty-three diverticula were found on the mesenteric border. Their walls were thin and translucent. Section showed the mucosa to be resting on the serosa.

Terry and Mugler reported a case of a woman, aged fifty-nine years, with symptoms of a duodenal ulcer. At operation they found an ulcer and also five diverticula on the mesenteric border of the jejunum. The two largest ones were inverted. Eighteen months later this patient became acutely obstructed and at exploration they found that an enterolith had formed in one of the diverticula and had encroached on the lumen of the upper jejunum.

Treatment.—It would not seem that the treatment of diverticulosis of the small intestine should arouse any great controversy. It is well known that there is no definite syndrome associated with diverticulosis of the small intestine; hence, a clinical diagnosis is unknown, and the fact that it is found so rarely in Röntgen-ray examinations leaves mainly the surgical exploration and the autopsy as a means of diagnosis. If this condition is found by Röntgen examination, then the severity of the symptoms should determine whether or not medical or surgical management should be carried out. If the symptoms are not severe enough to justify an exploration, then a bland, low-residue, anticonstipation diet with mineral oil would seem the most feasible. If, however, the symptoms are grave enough to justify surgical exploration, it must be determined whether or not the condition warrants a major surgical procedure, such as resection of a large portion of bowel. If, to cite an imaginary case, one were to find at exploration diverticulosis, involving several feet of the small bowel and diverticulitis of only one sacculation, would it be justifiable to resect all of the involved intestine, or would it be enough just to excise and turn in the part which was inflamed? It would seem that each case should be a rule unto itself.

Gordinier and Sampson report their case, which was partially obstructed due to changes which had taken place in one of many diverticula. After palliative measures had failed, they resorted to operation and found the above condition. Their procedure was to excise the distal cystic portion of the partially obliterated diverticulum and reinforce its base with catgut. Nothing else was done for the following reasons: (1) the intimate relation between the diverticula and the large blood-vessels; (2) the diverticula had been present for a long time and only one had given rise to any symptoms; (3) their situation in the upper portion of the circumference of the intestine and between the folds of the mesentery insures better drainage of their contents and also greater protection from secondary pathological changes than in diverticula arising from the free border; (4) the fluid content of the small bowel and the patent, broad orifices make it unlikely that trouble will arise from fæcal accumulations, and (5) one hesitates to resect over forty centimetres of small intestine unless it is absolutely necessary.

It is not known just how many vague, undiagnosed abdominal complaints are due to diverticulosis of the small bowel, and unless definite pathological changes take place, which are severe enough to justify operation, there is little chance of this condition being diagnosed. Stelton diagnosed a case by Röntgen-ray, explored it and found two diverticula high in the ileum, on the mesenteric border, which were decidedly injected. He ligated and excised the sac with relief.

MacKechnie says the treatment is purely palliative. He states that the physiologists teach us that next to the contents of the duodenum, those of the jejunum are the most toxic of the gastro-intestinal tract. The broken-up foodstuffs are quite toxic and if they

are delayed in their passage an undue amount of toxins gain entrance to the circulation. He advises careful control of the diet and excreta to control toxæmia. He says that the diet should be low in proteids as they are the most toxic. If surgical intervention is necessary, he suggests inversion, excision or resection, as seems most suited.

In Braithwaite's case, which had synovitis of the knee associated with the abdominal complaints of dyspepsia, pain and nausea after food, at operation he found many diverticula of the small bowel. The first one was at the duodenojejunal junction. He thought that owing to the pressure of the diverticula at this point, excision was inadvisable, and he did a lateral anastomosis below the diverticulum. His result was poor, so at a secondary operation he inverted the first one and resected the portion of the bowel below which contained the sacculations. He was able to follow this case for three months and during this time the patient was free from all symptoms.

Spriggs and Marxer suggest aid in emptying the pouches, thus preventing or diminishing the putrefaction of contents, to lubricate and disinfect its contents, and to correct or relieve any accompanying disorder and raise the tone of the alimentary canal of the body generally. They state that the benefits derived were much greater than were expected from a prior consideration of the anatomical condition and the symptoms. Having the patient lie on the side which would tend to empty the diverticula, for a period and of a half hour, about three hours after the meal is taken, they gave liquid paraffin twice daily. For relief of distention they gave cream of magnesia or a carminative mixture. Those with achylia received acid. A well-cooked plain diet with no condiments or foods known to disagree was given; the fruits and vegetables were puréed or sieved. An anti-constipation diet and regular exercise were advised. They claimed that two-thirds of the patients had their symptoms completely allayed after a few weeks.

Case assumes that since the contents of the small intestine are liquid, and in the jejunum fairly sterile, that the jejuno-ileal diverticula in the average case may be considered as causing no trouble and generally demand no surgical attention.

Jordan and Lahey state that the logical treatment of diverticula is resection, but that resection is often impossible because of their location and that from the point of view of therapy, therefore, the location of the sac is of prime importance.

Diverticula of the Duodenum.—Lockwood describes two types of duodenal diverticula. The developmental type, which occurs within three centimetres of the ampulla of Vater, usually proximal and rarely inflammatory. He questions whether these demand surgery.

The acquired type is generally supposed to be due to a "blow-out" from pressure within the bowel, of the contracting scar tissue about a healed ulcer. They usually occur, so he states, in the inner, anterior-inferior border of the duodenum, retroperitoneally. Approximately two-thirds are single and one-third multiple. They are most common in patients past middle life.

He states that the patients usually complain of pain in the epigastrium, directly over the diverticulum, immediately after eating. Pain is severe and is associated with a sense of distention, but without bloating. They may be nauseated and always get relief by vomiting—deep soreness may persist. The pain may extend to the back. The patient can usually place his finger over the site of the diverticulum. They dread food and avoid it, hence may lose much weight and are anæmic and generally below par. Unlike an ulcer, food aggravates the pain.

Although the history is suggestive, fluoroscopical examination should be relied upon. The treatment in his opinion is surgical. The sac should be excised, inverted and sewed over. If the sac is not readily discovered, open the duodenum, insert a finger in the sac and then free it up and excise. Diet may benefit some but will not cure.

He states that he has observed thirty-seven cases and has operated on nineteen. In the Lockwood clinic duodenal diverticula were found in approximately 1.7 per cent. of the gastro-intestinal röntgenoscopical routine examinations.

Nagel reports 2.2 per cent. of the developmental type in a series of autopsies, all occurring in adults with an average age of sixty-one years. They were all found within three centimetres of the ampulla of Vater. None of them showed any signs of an inflammatory process. In four of his cases there were multiple diverticula of the colon and one of these had multiple jejunal diverticula also. This association indicated, he believed, a developmental weakness in certain portions of the intestinal musculature.

He believes that the acquired type form a more important group. They are usually associated with duodenal ulcer. The majority form just beyond the pylorus, in the anterior-inferior portion. All coats of the bowel are included in their walls. He does not believe that they are formed by perforation of the base of an ulcer, but by the contraction of scar tissue and by pressure from within the bowel.

The symptoms, he believes, are those of the primary lesion, and the fact that many are atypical of duodenal ulcer can hardly be considered significant since this is true of many uncomplicated cases also. He believes operative treatment should be made to suit the individual exigencies demanded in each case. He found two which had apparently formed a fistulous tract between the gall-bladder and duodenum.

Scott's experience leads him to believe that diverticula arising from any part of the duodenum eventually produce some form of abdominal disturbance or distress, whether from direct or reflex causes, and in some cases this may even be of an acute nature, although more frequently it is met with as a chronic condition which he calls "diverticulitis duodenale."

He places this condition in the list of undiagnosed causes of the condition known as "chronic abdomen," which in his experiences he believes is due, more often than not, to one of the following, placed in order of frequency: (1) Duodenal ileus; (2) splenic drag (incomplete enteroptosis); (3) duodenal diverticulum.

He believes clinical diagnosis is practically impossible, due to the wide variety of symptoms. It is a mistake to conclude, so he says, that because a diverticulum, found by chance at necropsy, shows no evidence of inflammation, that therefore it gives rise to no symptoms during life. Considerable abdominal distress may result from the indirect effect of its presence. A reflex resulting in a spasm of the pylorus or forcible peristalsis of the duodenum, a form of duodenal ileus, may lead to definite attacks of pain and vomiting.

In his search of the literature on the development of these sacculations, he found that it has been shown that in the process of development, embryos of about thirty to sixty days show multiple vacuoles or pits, which give rise to local bulgings in the wall of the duodenum. He thinks, however, that it is open to discussion whether these play any part in the ultimate formation of diverticula. While granting that a congenital weakness of the wall originally exists, what mechanism is responsible for the gradual pushing out or for the localized bulging of the wall? Obviously there must be some form of internal pressure or stress. Now in the normal duodenum this internal pressure is not high and certainly not sufficient to create the force required to "balloon" or blow out this inherent weakness of the wall. In most cases a careful history will elucidate the fact that, as a child, "bilious attacks" were experienced. These attacks usually persist, three or four years being usual, until later years they become more frequent and severe, and in most cases the patients seek medical advice between the ages of twenty and forty.

He was struck with the similarity between the history of diverticula of the duodenum and that of duodenal ileus. In the cases that he examined personally, duodenal ileus was present in first, second, or third degree. This suggested to him the possibility that here was the increase in tension in the duodenum necessary to produce the gradual local distention or bulging. He asks, is this obstruction which is noticed at the duodenojejunal junction, caused by reflex spasm, analogous to that of the pylorus, in fact a reflex set up by the pressure of the diverticulum, or does the diverticulum originate from the combined efforts of a local weakness and a congenital type of duodenal ileus?

Kirklin, in his discussion of Lockwood's paper, states that many diverticula of the duodenum are seen in routine fluoroscopical examinations, but that unless the diverticulum is large, no mention is made of it in a report. He states that those in the first portion of the duodenum are apparent usually and are really due to pouching produced by a duodenal ulcer.

Sanders, in his discussion of the same paper, says that he has found an incidence of 0.9 per cent. in 1,540 gastro-intestinal X-ray studies. He has been unable to classify the symptoms.

In the X-ray department at The Mayo Clinic during a five-year period the incidence of duodenal diverticula which were seen and thought to be large enough to warrant reporting was 0.1 per cent. Many other small ones were seen but not reported. It has not been our experience that diverticula of the duodenum present as clear-cut a history as Lockwood reports. It would seem that diverticula of the duodenum *per se* are of no great importance but are just another possibility to be ruled out in upper gastro-intestinal studies and another complication of duodenal ulcer.

X-ray.—The honor of being the first to record an X-ray diagnosis of diverticula of the small bowel and to have it subsequently proven at operation belongs to Case. He exhibited two cases in 1915 before the American Röntgen-ray Society which he had diagnosed by X-ray and subsequently proven at operation, and reported them in 1920. In 6,847 complete observations of barium meals, he and his associates recorded characteristic evidence of duodenal diverticulosis in eighty-five, diverticulosis of the jejunum in four cases, and of the jejunum and ileum in one case. Only the two were subsequently proven up to 1920.

This evidently stimulated the röntgenologists to be on the lookout for this condition, for soon after Stelten reported a case of a male aged thirty-eight which he diagnosed by X-ray and was subsequently proven at operation. In the same year, Hurt and Cook report an X-ray diagnosis with confirmation at operation.

Braithwaite, in 1924, reported a case which in 1916 was diagnosed by Rowden, an associate of his, as pouches in the small intestine. He confirmed this in 1917. Not until 1922 did this patient come to operation and at this time Rowden's diagnosis was confirmed.

Baastrup, in 1924, reported a case by X-ray and confirmed it by operation.

Rothschild, in 1925, reported a case in which the X-ray diagnosis stated that "there is a retention of the barium meal in the small intestine apparently near the duodenojejunal junction which is constant and may be due to a diverticulum or an old inflammatory adhesion or a perforated gastric ulcer." Operation showed a diverticulum four inches below the duodenum.

Case says that the röntgenological findings are characteristic. With the patient in the erect position, the diagnosis of jejuno-ileal diverticula will be based on the discovery of one or more persisting barium shadows, hemispherical in outline, each shadow presenting a fluid level surmounted by gas. The outline of the "tic" will therefore be more or less rounded, the oval being divided into two zones, the upper half containing gas, the lower half filled with opaque material. This picture is obtained especially in the upper jejunum. Lower down towards the ileum the ovoid outline of the diverticulum may be divided into three zones: an upper zone of gas and a lower one of barium, separated by a middle zone representing the level of supernatant, only slightly opaque fluid, probably largely composed of intestinal secretions. In other words, there will be in the lowermost zone opaque material which is surmounted by somewhat less opaque fluid, and this in turn surmounted by gas imprisoned in the "tic."

This fluid level should also be demonstrated with the patient in the lateral position. It must be differentiated from levels of air or gas in obstructed loops of small or large

bowel as in cases of tuberculous peritonitis or multiple post-operative adhesions. Sometimes dilated portions of the colon may retain enough fluid and gas to show levels which might suggest the diagnosis of diverticula of the small intestine. Only rarely can one make a diagnosis of diverticula of the small bowel when the patient is studied only in the horizontal position. In this position, the chief sign is a persisting barium shadow, constant as to size and shape, but movable both spontaneously and under palpation. Sometimes the barium is held in the sacculations for many hours—twenty-four is not uncommon—and therefore subsequent observations should show progressively decreasing amounts of stagnant barium in the sacculi. He states that probably never will a case come to the röntgenological examination with a correct tentative diagnosis of jejuno-ileal diverticulosis. Out of approximately 10,000 consecutive barium-meal examinations, he made the diagnosis of diverticulosis of the jejunum and ileum in only ten cases. He states that in a series of autopsy cases at Johns Hopkins, one case of diverticulosis of this portion of the intestine was found in 200 cases. He concludes, therefore, that Röntgen-ray methods do not permit us to make a diagnosis of small intestinal diverticula in more than one case out of four or five where they are actually present.

In the routine Röntgen-ray examination of the stomach with an opaque meal the incidence of diverticula of the duodenum, exclusive of those associated with duodenal ulcer, is rather high as compared with the finding of diverticula in other portions of the small intestine. As a rule, the sacculations in the duodenum are single and situated in close proximity to the ampulla of Vater. When multiple diverticula of the duodenum are present, other diverticula in the small intestine should be sought for, as the two conditions are frequently co-existent. These are best demonstrated by observing the progress of an opaque meal in the small intestine with the röntgenoscopical and röntgenographical studies at frequent intervals.

At The Mayo Clinic during the five-year period from 1927 to 1931, 72,715 Röntgen-ray examinations of the stomach were made. During this period there were reported 111 diverticula of the duodenum, either single or multiple. During this same period, 956 stasis examinations of the small bowel were made, and in only three instances was diverticulosis of the small bowel reported.

From this series, it is evident that the incidence of diverticulosis of the duodenum was one in 655 routine Röntgen-ray examinations of the stomach, and one case of diverticulosis of other parts of the small bowel in 479 examinations where especial effort was made to find anomalies in parts of the small bowel other than the duodenum.

Spriggs and Marxer state that in a series of 1,000 consecutive gastro-intestinal Röntgen examinations, they found 143 patients who had one or more diverticu'a in the entire gastro-intestinal tract. Of these, seven were in the jejunum, four of which also had them in the duodenum. In the ileum, excluding Meckel's, there were also seven. This is an unusually high incidence, of fourteen small bowel diverticula in 1,000 Röntgen-ray examinations.

Case does not state whether or not he viewed all of his 10,000 cases in the different positions that he describes for the diagnosis of diverticulosis or whether or not they were all observed after the meal had had sufficient time to traverse the whole of the small intestine.

If, on the basis of routine stomach and duodenal examinations with the opaque meal, a comparison were to be made, it would be found that whereas he found one in 10,000 cases, The Mayo Clinic series would show approximately one in 36,357, a much lower ratio. From this it appears that Röntgen-ray diagnosis of diverticula of the small intestine, excluding those of the duodenum, is a rarity. However, the diagnosis of diverticulosis of the colon, with which this paper does not deal, is not uncommon. During this same five-year period, there were 27,006 colons examined by means of a barium enema, and diverticula noted in 1,562, an incidence of one in seventeen.

Résumé of Case Histories.—The cases of diverticulosis of the small bowel, other than those involving the duodenum and Meckel's, recorded at The Mayo Clinic, up until July 19, 1932, were gone over in an attempt to correlate the symptoms relative to diverticulosis. Only fifty-two cases were found. Thirty-eight of these were males, fourteen females. The average age was 55.6 years. The youngest was a male twenty-one years of age. The diverticulum in this case was in the lower ileum and emptied rather easily. The appendix was found to be chronically inflamed and was removed. Nothing was done to the diverticulum.

The oldest case was one of a woman eighty-two years of age, who died of pneumonia. Multiple diverticula were found, at autopsy, in the terminal ileum. She gave no history of any gastro-intestinal complaint. The oldest cases in which diverticula were found at operation were two patients, each sixty-eight years of age. One, a woman, had a high intestinal obstruction and at operation was found to have a diverticulum eighteen centimetres from the duodenojejunal junction. The jejunum was dilated about three times normal size; the diverticulum appeared about the middle of the dilated portion. Some adhesions were found but none that was totally obstructing the lumen.

The male, aged sixty-eight years, gave symptoms of epigastric burning three or four hours after meals with some weight loss. Exploration revealed a diverticulum situated about two inches below the ligament of Treitz. At operation, excision of the diverticulum, appendectomy and separation of Lane's kink were done.

Twenty-four of the fifty-two cases had single diverticula; twenty-eight; had multiple diverticula. Twelve had diverticula elsewhere in the body: some in the sigmoid, some in the bladder and some in the pharynx. Thirty-nine had diverticula in the jejunum, eleven were found in the ileum and in two cases diverticula were found in both.

Thirty of the fifty-two patients gave varying symptoms relative to the gastro-intestinal tract, generally consisting of belching, bloating, and minor abdominal pains. Eleven of the thirty had a rather typical gall-bladder history and a cholecystectomy was done on them. Four of these eleven had additional operations, either on the stomach, duodenum or appendix.

Diagnosis was made by röntgenogram in only three cases, all of which were in the jejunum and two were confirmed at operation. This number were found in 72,715 routine barium meals from January, 1927, to February, 1932. Two of these three were found in stasis X-rays. During this same period a much larger number of duodenal diverticula were found but no great significance was attached to them. Twenty-seven thousand and six barium enemas were done during this time and 1,562 patients were reported as having diverticula in the large bowel.

The frequency with which diverticula of the small bowel, other than those of the duodenum and Meckel's, is found by röntgenogram is one in 24,238 in this series of cases. On the other hand, the frequency of diverticula of the large bowel is one in seventeen cases examined.

At operation, for other causes, diverticula of the jejunum and ileum were found eighteen times. A side-to-side anastomosis was done from above to below the diverticula in one case. Invagination alone was done twice. Excision and invagination were done in two cases. In the case in which the side-to-side anastomosis was done, the röntgenoscopical report was "suggestion of small bowel obstruction." At operation multiple diverticula were found extending over eight to ten feet of the jejunum on the mesenteric border. In one case, no definite pre-operative diagnosis was done and at exploration a large diverticulum was found quite close to the ligament of Treitz. Excision of the diverticulum, an appendectomy and a separation of Lane's kink was done.

At no time did a patient go to operation for relief of symptoms thought to be caused by diverticula. Many of the diverticula found showed no evidence of being the seat of any disease and consequently nothing was done in most cases.

In one case there was a band of adhesions just below a diverticulum in the lower ileum. Whether or not this was a causative factor in the formation of the diverticulum is not known.

Thirty-one of the diagnoses were made at post-mortem, but in no cases were the diverticula found to be a contributing cause of death.

Hence it may be deduced from this series of cases that diverticulosis of the small bowel, *per se,* has no distinguishing feature and in most cases gives rise to no serious consequences. They do not seem to be as prone to diverticulitis as those of the large bowel. This is probably due, in a large degree, to the fluidity of the contents of the small bowel as compared with the more solid contents of the large. The absorption of water being greater, and hence the contents of the pouch being more dehydrated and less easily evacuated from the diverticulum, solids remain in the pouch and possibly predispose to infection. The percentage of diverticula which go on to diverticulitis, however, is very small even in the large bowel.

Even when a diagnosis is made by röntgenogram and all other pathology ruled out, the severity of the symptoms should be studied carefully, and this alone should decide whether or not surgical intervention should be carried out.

One of our cases was a dentist, quite high-strung and hard working. His symptoms were of such severity at times that cholelithiasis was the first thing thought of by many men whom he had seen. His upper abdominal pain was severe enough at times to require morphia for relief. However, he nor the clinicians nor the surgeons thought that the attacks were frequent enough to justify resecting a large section of the small bowel. He was placed on a bland, low-residue diet and instructed to report if he had trouble. No word has come from him in eighteen months.

CONCLUSIONS

Diverticulosis of the small bowel is much less frequent and gives rise to much less trouble than diverticulosis of the colon.

Diverticulosis of the small bowel, other than that occurring in the duodenum and the diverticulum described by Meckel, is found about once in 25,000 X-ray examinations.

The relative frequency with which duodenal diverticula appear, as compared to others in the small bowel, excluding Meckel's, makes it seem that clinically they are of less importance.

No typical chain of symptoms can be ascribed to this type of diverticulosis. In unexplained abdominal complaints diverticulosis must be thought of, however, and ruled out.

If a large section of the bowel is involved, surgery must be considered guardedly.

A careful medical management seems to be the best procedure usually, although occasionally surgical intervention seems warranted.

POLYCYSTIC DISEASE OF THE KIDNEY

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Polycystic kidney disease is of more than passing interest to both the clinician and the surgeon. In the first place, while not a common condition, it is by no means rare. In collected statistics of 23,900 autopsies, sixty-seven cases of bilateral polycystic kidneys were found.[1] In a local hospital, thirteen cases occurred in 2,060 autopsies.[2] In our series, there were sixty proved cases in 220,000 admissions, a ratio of 1:3,500, and out of a total of 6,000 necropsies, fourteen cases were encountered or a ratio of 1:428. The Mayo Clinic had an incidence of 1:3,523 in 680,000 registrations and of 1:1,019 in 9,171 autopsies.[3] In any fairly large hospital, three or four of these cases will be seen each year.

From a practical viewpoint, the methods of diagnosis are important. While often the picture is typical, there are times when a differential diagnosis must be made from malignant neoplasm, bilateral hydronephrosis, pyonephrosis, calculous disease of the kidney, and chronic cardiovascular renal disease.

The pathogenesis of polycystic disease of the kidney has been the subject of many investigations, but in spite of a large amount of research, none of the theories of etiology completely explains all the pathological and experimental data. Moreover, the operative indications for its treatment have not been standardized, and should be revaluated in the light of present knowledge and past experience.

Polycystic kidney disease should be defined in contrast to other cystic conditions of the kidney whether single, multiple, or multilocular. Small epithelial-lined cavities are found in kidneys at all age periods.[4] According to Lubarsch,[4] they increase numerically with age. In the newborn and up to one and a half years of age, more than 50 per cent. of kidneys show such cysts according to Rückert,[5] Herxheimer,[6] and Braunwarth.[7] The dividing line between simple cysts and polycystic disease is not clear cut. Thus, the microscopical appearance of a single cyst from a polycystic kidney may present the same features as one of the multiple cysts found in arteriosclerotic kidneys. For example, both types may have thin walls surrounded by compressed, fibrosed kidney tissue and lined by a layer of flattened epithelial cells. A kidney may be considered "polycystic" when there is an excessive number of small and larger cysts found throughout its parenchyma and projecting on its surface. Both cortex and medulla are involved; sometimes one more than the other. There may be a large amount of fairly normal parenchyma left or there may be complete gross absence of renal tissue depending on the stage reached. While there may be some evidence to explain most types of cysts on a con-

genital basis (see Orth[8] and Kampmeier[9]), in this study only kidneys which have the gross characteristics above described are considered truly congenital polycystic. These alone are associated with other well-known characteristics such as familial and hereditary tendencies, bilaterality of occurrence, and the symptom complexes to be described below. The consideration that a gross pathological diagnosis of polycystic kidney depends upon the excessive degree of cystic involvement is important, too, in the evaluation of unilateral cases. When one kidney is grossly polycystic, the presence of occasional cysts of microscopical size in the opposite kidney would not compel a diagnosis of bilateral polycystic kidney since such occasional cysts are often found in otherwise normal kidneys. If, however, such a kidney shows a really extreme number of small or microscopical cysts such as would undoubtedly go on to the formation of a grossly polycystic kidney as already apparent in the opposite kidney, the diagnosis of bilateral polycystic kidney is justified.

This study is based on sixty cases observed between the years 1911 and 1932. Six were from the office of Dr. Edwin Beer and fifty-four were admitted to the Mount Sinai Hospital, New York City. Fourteen of these patients came to post-mortem examination.

Polycystic kidney disease is known clinically in two forms, *i.e.*, in the newborn and in adults. The former is seen more often in the lying-in hospitals and is frequently associated with various other congenital anomalies, some of which may be incompatible with life. These anomalies run the whole gamut of developmental imperfections such as hare-lip, cleft palate, hypospadias, rudimentary external genitalia, vesico-rectal fistulæ, bladder malformations, atresia of the vagina or rectum, imperforate anus, malformations of the sigmoid, cardiac malformations, uterine aplasia, polydactylism, club feet, meningocele, hydrocephalus, spina bifida, and porencephaly.[1, 5, 10, 11, 12] While anomalies occasionally occur in the adult cases, they are not common. No malformations were noted in this series.

Cases of dystocia due to cystic kidneys are well known and of importance to the obstetrician. In fact, the earliest described cases of polycystic kidney were those encountered as a cause of obstructed labor reported by Alexis Littré[13] around 1700 and by Othmar Heer[14] and by Osiander.[15] Almost yearly such case reports occur in the literature.[17, 18, 19, 20]

Many of the newborn cases die at birth or shortly after. The rest are unrecognized and reach adult life before presenting signs and symptoms of their condition. A few infants, however, live to develop symptoms or die of intercurrent disease before the age of two or three. In such instances the syndrome of renal rickets or renal dwarfism may be present, as seen also in chronic nephritis, with bone changes and disturbances in the calcium and phosphorus ratio in the blood. (Mitchell,[21] Green.[22])

There is only one newborn case in this series, a six-month-old female child, admitted to Doctor Schick's service, with clinical signs of nasopharyngitis and pneumonia. She had been born as a seven months' premature infant. Death occurred after a nine-day illness, and post-mortem showed bilateral

polycystic kidneys, each the size of a hen's egg, hypertrophy of the left ventricle and fatty infiltration of the liver. Three other infants had been born to the same mother and had died, one at seven days, one at two days, and one a stillbirth in the seventh month of gestation. Since there was no evidence of lues, the possibility must be considered that the other infants had congenital malformations, in particular, polycystic kidneys.

The remaining fifty-nine patients were of the adult type. The following data are based on their study.

Sex.—Thirty-seven patients were males and twenty-two were females.

Age Groups.—The age groups are seen in Table I.

TABLE I

Years	No. of Patients
1–9	0
10–19	0
20–29	2
30–39	14
40–49	17
50–59	18
60–69	8

These represent the age when the patient first came under observation. It should be noted that the great majority of cases on admission were between the ages of thirty-five and fifty-five. The average age of the patients at the onset of their symptoms was calculated as being 41.5 years. From this table, there is evident a wide age gap between the newborn and infant cases and the adult cases. This had been known to Virchow[23] who, however, was unable to explain it. This occurrence is the basis of the contention on the part of some observers that the newborn and the adult forms represent different diseases.

It is our belief that the tremendous margin of safety present in the kidneys explains the fact that cases remain symptomless during the first two decades of life. In our own series a female patient, first seen by us at the age of thirty-seven, had had a nephrectomy for polycystic kidney at another hospital

TABLE II

Stillborn or dying shortly after birth	59
Died in 1st year life	10
1–5	6
5–10	1
10–20	4
20–30	22
30–40	24
40–50	53
50–60	41
60–70	10
70–80	6
80–90	3
Total	239

at the age of twenty-three. Undoubtedly, she must have had the condition for a number of years previous to this. Another female patient had symptoms which started at twenty-six. She was first observed at twenty-eight and finally died in this institution in uræmia at the age of forty.

Küster[24] has published an interesting table of age groups of collected cases from the literature which some recent authors have erroneously attributed to Stromberg. (See Table II.)

Particularly important are the cases between two and twenty. Küster found the following cases:

TABLE II

	Years
Park	2
Hildebrand	2
Graser	2½
Ore	2½
Talamon	5
Orth	14
Harris	18
Beckmann	19
Höhne	20
Johnson	20
Gairdner	18
Israel	15*

* This patient died at twenty-five with symptoms of ten or fifteen years' duration.

From Albarran and Imbert,[25] Sieber[26] quotes the following cases:

	Years
Jacobson	2½
Steiner	10
Steiner	10
Heimann	11
Lucet	17
Edmunds	18
Bar	19

Sieber[26] found the following additional cases:

	Years
Meyer	2
Meyer	6
Meyer	9
Türk	17
Richmond	18

A casual search of the recent literature reveals the following cases:

Willan[27] 17—female died in uræmia at 31, known to have a kidney tumor when a few months old; symptomless until age of 17.

Rossen[28] 9—at onset of symptoms—died at 14.

Cumming[29] 14—at death—treated for nephritis since 6 years old.

Halbertsma[30] 10—girl with unilateral mass, hypertension, typical pyelogram, hæmaturia, whose father had the same condition.

Schapiro[31] 10—boy who was examined at 10 for polycystic kidneys because of a pronounced familial history. At 13 had a trace of albumin in his urine. Rejected for life insurance at 19 years at which time both kidneys were enlarged and nodular.

The occurrence of these twenty-nine cases between the ages of two and twenty would seem to be a connecting link between the newborn and adult types of the same disease.

Mortality and Follow-up.—Twenty-six of the fifty-nine patients or approximately 43 per cent. are known to be dead. The average age at death was fifty years. The earliest death was at twenty-six years while the latest age at death was sixty-eight. In general, then, these individuals have a life expectancy of about ten or twelve years less than that of the average individual. Of the living patients, seven have been followed regularly to the present time, while the remaining twenty-six cases, although followed for varying periods of time, have an incomplete follow-up record. The total duration of the patients' symptoms, calculated from the history and time under observation until the last follow-up date or until death, is given in Table III under these headings, *viz.*: for the cases that died, for those with a partial follow-up, and for those with a complete follow-up.

TABLE III

Duration of Symptoms	Number of Cases		
	Died	Partial F.U.	Complete F.U.
Less than 1 yr.	3	6	0
1 yr.	1	4	0
2 yrs.	6	3	1
3 yrs.	3	2	0
4 yrs.	1	1	2
5 yrs.	2	1	2
6 yrs.	2	1	1
7 yrs.	1	3	0
8 yrs.	1	0	1
9 yrs.	0	1	0
10 yrs.	2	1	0
12 yrs.	1	1	0
13 yrs.	1	0	0
14 yrs.	1	2	0
19 yrs.	1	0	0
Total	26	26	7

The tendency to chronicity and long duration of symptoms is well illustrated. Ten cases had symptomatic evidences of their condition for ten years or more.

Familial and Hereditary Factors.—The frequent occurrence of multiple cases of polycystic kidney in the same family is well known. This hereditary predisposition appears to be equally transmitted by either sex. The literature is replete with such reports, the most remarkable being that of Crawford[32] who found seventeen cases in a family of forty members. Dunger,[33] Bull,[34] Borelius,[35] Osler,[36] Bunting,[37] Wobus,[38] Cumming,[29] and many others have

confirmed this hereditary tendency which, together with the frequency of occurrence of newborn cases and of other congenital anomalies, proves the congenital nature of the disease. In this series there were eight cases (about 14 per cent.) with a proved familial history of polycystic kidney disease. Of these, two were brothers, and three were father, son and daughter. The sixth patient had a brother who died of the condition, the seventh had an aunt who died of it, while the eighth had a sister who died at another hospital following a nephrectomy for polycystic kidney. Besides these eight patients there were three others with a probable but not proved familial history.

Unilateral Polycystic Kidney.—There were no proved unilateral cases in this group. For practical purposes every case of polycystic kidney may be considered bilateral. However, the incidence of the unilateral form of the disease in different series varies considerably. Lejars[39] found three unilateral cases in sixty-two cases. Ritchie [40] found two in eighty-eight cases autopsied. Naumann[41] found two unilateral and fourteen bilateral cases in 10,177 necropsies. Bugbee and Wollstein[12] found four unilateral and eleven bilateral cases in 4,903 necropsies in infants. Dickinson[42] thought the ratio was about 1:26 while Luzzato[43] believed that 18.1 per cent. of the cases were unilateral.

Undoubtedly some of the statistics based on clinical data are not entirely accurate. Simple palpation at operation alone cannot be relied upon for proof that the non-nephrectomized kidney is normal, despite clinical reports to the contrary[44]. It is an important surgical fact that when nephrectomy has been done for polycystic kidney in a case in which the second kidney had appeared normal to the surgeon's palpating hand, the latter kidney is very likely to become polycystic subsequent to the operation. Reimann[45] saw three such cases. Barnett[46] changed his earlier views on unilateral cases; one of his cases reported originally as unilateral which had been subjected to nephrectomy, developed five years later signs of involvement of the remaining kidney with anuria. Of nine patients diagnosed as having unilateral disease in 1912, Barnett found that five developed polycystic changes in the other kidney by 1917.

It is probable that in some of the cases included in the post-mortem statistics quoted above concerning unilateral polycystic disease, complete microscopical study of the grossly uninvolved kidney was not done. Undoubtedly, as Barnett claims, many more cases would show microscopical cysts in sufficient number to be included with the cases of bilateral disease than such statistics would indicate. In conformity with this is the viewpoint expressed by Braasch and Schacht[3] who state that "polycystic kidney is always bilateral in the adult." Nevertheless undoubted cases of unilateral cystic disease must exist as in the following two cases which were very kindly placed at my disposal by Dr. Max Lederer, pathologist to the Brooklyn Jewish Hospital. At that institution there were two unilateral cases and eleven bilateral cases found in 2,060 autopsies.

CASE I.—Italian male, 60 years of age. Admitted December 3, 1925, and died shortly after admission. He had had headaches, vertigo, and spots before the eyes for six months. Suddenly had an attack of apoplexy with unconsciousness. Became cyanotic with Cheyne-Stokes respirations and pulmonary œdema. He had a right hemiplegia. Blood-pressure 230/140. Phlebotomy and spinal tap performed.

Post-mortem.—Obese; heart enlarged, ventricular hypertrophy and dilatation; patent foramen ovale. Liver—no cysts.

Kidneys.—(Left.) Typical appearance of polycystic kidney (Fig. 1); was about twice the size of the right kidney, containing multiple cysts of varying sizes; only a portion of its upper pole was uninvolved. *Microscopically.*—The cysts showed the usual appearance.

(Right.) Contained no cysts; weighed 256 Gm.; many depressed areas on the surface.

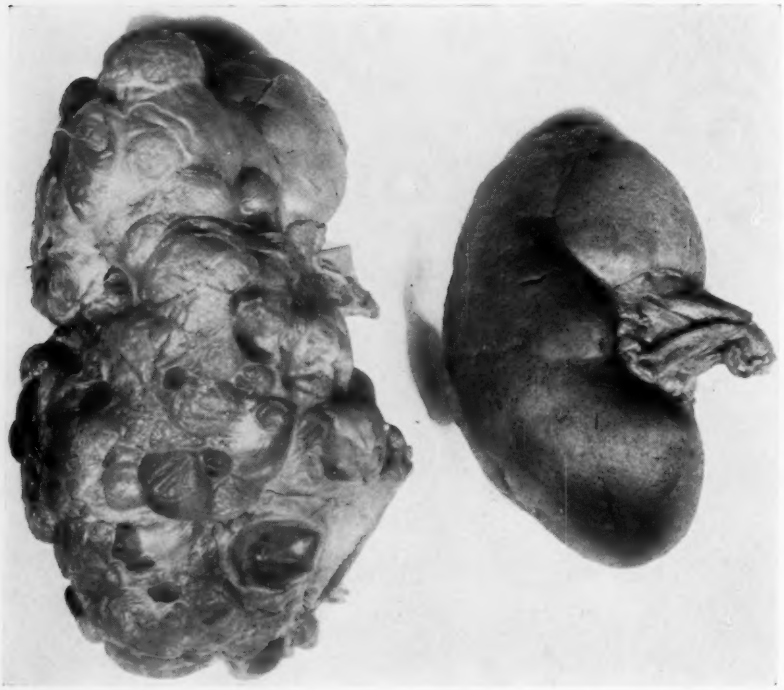

FIG. 1.—Unilateral left polycystic kidney. (Specimen in fixative for eight years.)

Microscopically.—Œdema and congestion involving glomeruli; smaller vessels sclerotic with associated areas of round-cell infiltration and focal fibrosis. An occasional small lacuna lined by flattened epithelium. The brain showed a cerebellar hæmorrhage.

Pathological Diagnosis.—Cerebellar hæmorrhage and cerebral arteriosclerosis. Generalized arteriosclerosis. Focal nephrosclerosis. Parenchymatous degeneration of the liver. Unilateral polycystic kidney.

CASE II.—Full-term, white, male newborn child, spontaneously delivered March 14, 1933. An imperforate anus was present for which a perineal incision and exploration for the rectum was performed. The rectum was not found and a left-sided colostomy was done. The sigmoid could not be brought to the perineum and was sutured to the abdomen. The infant expired eight hours post-operation.

Post-mortem.—The rectum was reduced to a fibrous cord for a distance of six centimetres and was fixed to the tip of the coccyx. The liver was normal.

Kidneys.—(Right.) Small, consisted almost in its entirety of numerous cysts con-

taining clear fluid; no renal tissue discernible. *Microscopically.*—It showed the picture of a polycystic kidney; there were individual normal groups of kidney parenchyma with well-preserved tubules and glomeruli, isolated by fibroplastic interstitial tissue which often appeared embryonal in character; many tubules dilated in cyst-like formation with flattened lining epithelium; larger and smaller cysts.

(Left.) Was increased in size over the normal; uric acid crystals present in the apices of the pyramids but otherwise it was normal. *Microscopically.*—Kidney appeared normal; no cysts present.

Pathological Diagnosis.—Atresia of the rectum with imperforate anus. Unilateral polycystic kidney. Pulmonary infarction. Bronchopneumonia. Incomplete spina bifida. Patent ductus arteriosus and foramen ovale.

Clinical picture on admission—Modes of onset or discovery.—The cases grouped themselves into eight main clinical forms as follows:

(1) Accidental discovery, as at operation, post-mortem examination or the findings of a symptomless mass in the abdomen..... 6 cases.

(2) Symptoms and signs of hypertensive cardiorenal disease. Malignant hypertension, primary arteriolosclerosis, and the later stages of chronic glomerular nephritis may give the same picture as the disease under consideration..... 13 cases.

(3) Symptoms and signs resembling those of renal neoplasm, namely, unilateral mass, pain, and hæmaturia..... 7 cases.
Of these the diagnosis in four cases was made by an exploratory lumbar incision.

(4) Symptoms and signs suggestive of infected hydronephrosis, pyelonephritis or perinephric abscess..... 3 cases.

(5) Cases with vague abdominal symptoms as abdominal pains, vomiting, eructations, constipation, and distention..... 5 cases.

(6) Frank symptoms and signs of polycystic kidney, namely, hæmaturia, loin pain, bilateral loin masses, arterial hypertension, and evidences of renal insufficiency..... 15 cases.

(7) Case with acute retroperitoneal syndrome..... 1 case.
An unusual case to be described later.

(8) Symptoms, signs and X-ray evidence of renal calculi..... 9 cases.

Points in history. Symptoms presented on admission or occurring during period of observation of the patient:

	Number of Patients		Number of Patients
Loin pain	28	Anorexia	8
Abdominal pain	21	Weakness	8
Hæmaturia	21	Dysuria	7
Nocturia	19	Fever	7
Loss in weight	18	Dizziness	7
Vomiting	14	History of hypertension	7
Tumor mass	13	Cough	6
Dyspnœa	12	Polyuria	5
Frequency of urination	11	Œdema	5
Headache	9	Constipation	5
Pyuria	8	Previous kidney trouble	5
Nausea	8	Oliguria	5

Polydipsia	4	Paræsthesias	2
Apoplectic stroke	4	Frequent colds	2
Previous operations for polycystic kidney	4	Drowsiness	2
		Gain in weight	2
Previous abdominal operation not for polycystic kidney	4	Restlessness	1
		Ecchymoses	1
Abdominal distention	2		

Physical Signs—

Kidneys:

Both kidneys palpable and enlarged	39	(66 per cent.)
Right kidney only, palpated	4	
Left kidney only, palpated	6	
Neither kidney palpated	10	

Of the last, four were cases which were discovered at post-mortem examination. The typical palpatory finding in a polycystic kidney is that of a firm, hard, nodular mass located in the loin or upper quadrant of the abdomen, which moves on respiration and which is distinctly ballottable.

Liver.—An enlarged, palpable liver was present in fifteen cases (25.4 per cent.). This enlargement had no relation to cystic involvement but was found to be due to parenchymatous or fatty degeneration, or to chronic passive congestion in those cases which showed cardiac weakness.

Heart.—An enlarged heart was present in nineteen cases (30.5 per cent.) as judged by physical examination, X-ray or post-mortem studies.

Vascular system.—Signs of peripheral arteriosclerosis were present in fourteen cases (23.7 per cent.).

Fundi.—There were ocular fundus changes in twelve cases. Many of the earlier cases did not have routine eye examinations, so that an estimate of the frequency of these changes in our cases is of no value. However, recent observers[3] found ocular abnormalities in 57 per cent. of their cases. In our series the changes were mainly vascular, *viz.*, angiosclerotic in nature, with occasional retinitis or hæmorrhagic retinitis.

Laboratory Data—

Urinary Findings. 42 cases (71 per cent.) showed from a trace to four plus albumin. 10 cases had casts in the urine. 30 cases were uninfected as judged by the urinary findings. 10 cases showed from occasional to many white blood cells. 19 cases (32 per cent.) showed clumped white blood cells to large quantities of pus in the urine.

Red blood cells were present in the urine at one time or another in 33 cases (56 per cent.). The frequency of red blood cells in the urine is easily understood according to Ritter and Baehr.[47] They state that while hæmaturia and hæmorrhage into cysts are not necessarily dependent on arterial hypertension, their likelihood is increased by its presence. By means of arterial injections they showed how the interlobar and interlobular arteries lie in the cyst walls. In the larger cysts there are numerous arteries of various sizes beneath the lining epithelium. As the cysts increase in size, the arteries do not stretch in proportion and come to lie in the cyst cavity in a falciform fold of lining epithelium, lying unsupported. Slight trauma, local vascular disease, and hypertension may easily cause hæmorrhage into cysts with lumbar pain and possible secondary rupture into a calyx with hæmaturia. Undoubtedly, in many instances the hæmaturia is due to venous stasis and congestion involving the pelvis and peripelvic tissues. The bleeding may result from direct rupture or from brisk diapedesis.

Tests of kidney function.—The concentration test (Volhard) showed a fixation of specific gravity at or below 1012 or 1014 in seventeen cases out of twenty-eight (61 per cent.).

Phenolsulphonphthalein Test.—This test was unrecorded in twenty-five cases. Out of thirty-four cases, the output in four hours was greater than 50 per cent. in seven. In

eleven cases it was between 10 and 40 per cent. In ten cases it was less than 10 per cent. while six cases had a zero output. In other words, twenty-seven out of thirty-four tested cases (79 per cent.) showed renal impairment by this method.

Blood Urea Nitrogen.—This was recorded in forty-five cases, as follows:

Under 20 milligrams per 100 cubic centimetres	12 cases
20 to 50 milligrams per 100 cubic centimetres	13 cases
51 to 100 milligrams per 100 cubic centimetres	4 cases
Over 100 milligrams per 100 cubic centimetres	16 cases

The highest was 190 milligrams. Thirty-three cases showed an elevated urea nitrogen at one time or another (73 per cent.).

As judged by laboratory tests alone, 71 per cent. of the patients, while under observation, showed evidences of renal impairment.

Blood-pressure.—The following figures represent the highest systolic readings in any case while under observation:

200 (or above) millimetres mercury	13 cases
160 to 200 millimetres mercury	16 cases
140 to 160 millimetres mercury	9 cases
120 to 140 millimetres mercury	5 cases
100 to 120 millimetres mercury	6 cases
Total	49 cases
Not charted	10 cases

The highest reading was 272/112. In relation to their age, twenty-eight cases (57 per cent.) showed hypertension while twenty-one cases did not. Twenty-two cases had a diastolic pressure of 100 or above.

Braasch[48] and Schacht[49] among others have commented on the frequency of significant persistent hypertension in these cases. They attribute the hypertension to a generalized vascular disturbance as shown by the high incidence of retinal sclerosis and to the findings of obliterative changes in the arterioles and small arteries of the kidneys. Hinman and Morrison,[50] and Ritter and Baehr[47] have demonstrated these renal vascular changes by their injection studies. Whether the vascular sclerosis, especially in the kidneys, is the primary factor, and the hypertension and renal functional disturbance secondary is a moot point.

Experiments in animals, producing varying reductions of the total renal substance, while not conclusive, have shed some light on the subject. Pässler and Heinecke[51] and Chanutin and Ferris[52] found that where a chronic state of renal insufficiency was thus produced, hypertension and cardiac hypertrophy resulted without vascular sclerosis. Cash[53] noted that where the total kidney mass was reduced by one-half (by nephrectomy), ligation of the blood supply to a portion of the remaining kidney was followed by an increased systolic and diastolic blood-pressure. In polycystic kidneys where the total functionating renal substance is so grossly reduced, it is conceivable that pressure effects on vessels may create a situation such as was produced experimentally by Cash with a resultant hypertension. The latter in turn would lead to a secondary vascular sclerosis.

The correlation between the blood-pressure and renal function in this series was more closely analyzed as follows:

Of 21 cases *without* hypertension in relation to age

In 11 the kidney function was normal
In 2 the kidney function was slightly impaired
In 8 the kidney function was poor

Of the latter eight cases, four had evidences of cardiac failure, one had bronchopneumonia and one was in collapse. Some of these cases had a history of preëxisting hypertension. Only two cases, then, with marked impairment of kidney function and without other complicating factors had normal blood-pressures.

Of 28 cases *with* hypertension

In 20 the kidney function was poor.
In 2 the data were incomplete on kidney function.
In 3 the kidney function was fair, *i.e.*, although there was no clinical evidence, there was laboratory evidence of beginning impairment, *e.g.*, normal blood chemistry and phenolsulphonphthalein output with diminution of concentrating power or perhaps urea nitrogen at upper limit of normal with moderate diminution of the phenolsulphonphthalein output.
In 3 the kidney function was normal. Of the latter group, one case while still under observation, showed beginning impairment of function.

The following three cases are illustrative of discrepancies which occur in attempts to generalize concerning the behavior of the blood-pressure in relation to renal function:

Case III.—Female patient; when first seen had slight elevation of blood-pressure with normal renal function. Twelve years later, had high blood-pressure with definite renal impairment. Here the hypertension preceded the impaired kidney function.

Case IV.—Female patient who had a normal blood-pressure with slight kidney insufficiency. Four years later had a severe hypertension with moderate kidney insufficiency, or impaired renal function preceded the hypertension.

Case V.—Male patient; at first observation had normal blood-pressure and renal function. Six years later, had hypertension with good kidney function.

From this study, however, it may be stated that hypertension in these cases is usually associated with evidences of renal impairment and *vice versa*, except in cases of cardiac failure or vascular collapse. Occasionally a case will be seen with impaired or very poor renal function and normal blood-pressure, and on the other hand hypertension will be noted with normal renal function or with only the slightest evidence of beginning renal impairment.

Incidentally, in the earlier stages of this disease renal impairment is not clinically evident and is found only by studies of the concentrating power of the kidney, the phenolsulphonphthalein test, and blood chemistry figures. As with certain other surgical diseases of the kidney, patients with polycystic kidneys can go about with marked azotemia yet without marked clinical signs and in apparent good health. We have often marvelled at such patients who have been observed with extremely high blood nitrogen figures and hypertension for four to six years before becoming clinically uræmic. This is accounted for only in part by the marked kidney reserve

we possess. Experimentally, Tuffier,[54] Bradford,[55] Allen, Scharf, and Lundin,[56] Paoli,[57] Chanutin and Ferris,[52] and others found that in different animals two-thirds to even one-sixth of the normal kidney tissue present was enough to sustain life. Smith[58] and Muslow[59] reported clinical cases of extreme diminution of kidney substance. This ability to live with such little kidney tissue is the one bright feature in congenital cystic disease and suggests the principle of treatment, namely, conservatism.

Blood Count Studies.—Those cases with a normal blood urea and phenolsulphonphthalein excretion had a normal high hæmoglobin and red blood cell count. Two cases with normal urea and phenolsulphonphthalein test showed a secondary anæmia. These cases had lost blood over a long period of time as a result of hæmaturia.

Out of sixteen cases with clinical and laboratory evidences of kidney insufficiency in which full blood count studies were made, two had a normal hæmoglobin and red blood cell count while fourteen showed anæmia with an average hæmoglobin of 63 per cent. The lowest was 30 per cent. The color index of these cases had a tendency to be higher than that of an ordinary secondary anæmia (0.7–1.0), *i.e.* approaching the type of a primary or pernicious anæmia. Brown and Roth[81] noted a relationship between anæmia and renal insufficiency, attributing the former to a disturbed hæmatopoiesis. In cases where there was marked infection in the kidney, the white blood cell count ranged between 16,000 and 28,000, and the polymorphonuclear leucocytes between 75 per cent. and 85 per cent. of the total.

Cystoscopy.—This was performed at least once, and sometimes more often in thirty-four cases. Diagnostically, it was of no help except to reveal the source of bleeding or the location of infection.

X-ray Studies.—Flat plates of the abdomen with the Bucky diaphragm were most helpful in suggesting unilateral or bilateral enlargement of the kidneys and calculi. The most valuable aid to diagnosis was pyelography, especially retrograde pyelography. Fifteen cases were diagnosed by retrograde pyelography and three by excretion pyelography. Of these, two cases had both retrograde and excretion pyelography. Retrograde pyelography was usually more helpful than excretory urography especially in cases with poor kidney function, rendering excretory urography impossible for exact diagnosis. In several cases, the retrograde pyelogram also was not diagnostic; 90 per cent. of the cases, however, showed a typical picture. The characteristic appearance of the pyelogram is well known and may be summarized as presenting a stretched-out, "spidery" appearance with sharp lines instead of the soft curving lines of the normal contour.

Where retrograde pyelography is necessary for diagnosis in cases with marked renal impairment, only non-irritating types of solutions are advised, such as those used for intravenous pyelography. Sodium bromide is contraindicated. No reactions have been seen when using iopax, skiodan, hippuran, or their derivatives for retrograde purposes.

Associated Lesions of Polycystic Kidney.—Cysts of the Liver.—There is a well-known and definite association of this condition with polycystic kidney disease. In fourteen post-mortem examinations, four cases showed cysts of the liver (28.5 per cent.). A fifth case had an exploratory operation with the evacuation of a large cyst of the liver. There were other small liver cysts present and by palpation, polycystic kidneys were noted. As a rule these hepatic cysts are very small and have no relation to the size of the polycystic kidneys. Lejars[39] in sixty-two cases found liver cysts in approximately 28 per cent. of the cases; Ritchie[40] in eighty-eight cases found a 25 per cent. incidence; while Küster[24] in 249 cases found the incidence to be 16.5 per cent. Moschcowitz,[11] in a very enlightening study, presented evidence to show that cysts of the liver were congenital anomalies which arose from dilatations of aberrant bile ducts. Cysts of the pancreas, spleen and other organs in association with polycystic kidney have been described but are very rare. Involvement of the pancreas has been observed by Kaufmann,[45] Braasch,[3] Bunting,[37] Sears[60] and others. One of our patients who had diabetes was thought possibly to have cystic involvement of his pancreas. He died at another institution, however, and unfortunately no post-mortem examination was made.

Other congenital anomalies, especially of the newborn, have been mentioned earlier in this paper. Other anomalies of the kidney itself are unusual and do not occur more frequently with polycystic kidney than in general. Washburn[61] reported an autopsy of a case with bilateral double kidneys. There were two distinct pelves and ureters on either side, with bilateral cystic involvement. Barnett[62] described a case of unilateral fused kidney; the upper kidney was polycystic while the lower, normal-appearing kidney contained a calculus. One of Wobus'[38] cases was a seven and one-half months' fœtus with a horeshoe kidney fused at the lower poles.

Incidental Conditions Found in Patients with Polycystic Kidneys.—Other diseases present were coronary artery disease, four cases; lues, gall-bladder disease, chronic phthisis, and pneumonia, twice each; and malaria, rheumatic fever, fibroid uterus, post-partum sepsis, diabetes, and lymphosarcoma, once. The presence of coronary sclerosis is easily understood, because of the high incidence of hypertensive vascular disease (24 per cent.). The patient with lymphosarcoma was a forty-four-year-old man with symptoms of malaise and weakness for five months with a tumor mass in the left upper abdomen for one month. The left pyelogram was somewhat suggestive of polycystic kidney while the right was normal. At exploration, besides a polycystic kidney, an adherent retroperitoneal mass was found, crossing the spine. Specimens removed were reported as being lymphosarcoma. Following his discharge from the hospital, the patient did not report to the radiotherapy department and was lost sight of.

Complications.—Calculi.—One of the surprising features of this study was the frequency of associated calculi. As determined by the history,

X-ray, operation, or necropsy, renal and ureteral calculi were present in fourteen cases (23.7 per cent.). This is a much higher percentage than recorded in other statistics. Sieber[26] found eight cases of calculi in 212. In general, the occurrence of calculi in polycystic kidneys is considered uncommon. Many single case reports of this association have been published such as that of Peacock and Corbett[63] who describe multiple bilateral calculi in a case of polycystic kidneys with successful operation. In this series, three cases were operated upon for their calculi. A fourth, a case complicated by an obstructing ureteral stone, was treated conservatively.

Rupture.—Rupture of a polycystic kidney has occurred. Traumatic rupture, following the kick of a horse, has been reported by Brin.[64] One of the cases in this group, non-traumatic in nature, will be described because of its unusual features.

Case VI.—B. C., male, aged fifty-eight, admitted with left lower quadrant pain of eighteen hours' duration. History of hypertension (220) for many years, also left lumbar colic with passage of stones four years previously.

Physical Examination.—Left costovertebral tenderness and mass in the left iliac fossa. Hæmoglobin, 45 per cent.; white blood cells, 17,000, with 79 per cent. polymorphonuclear leucocytes. Urine: albumin 2 plus, clumped white blood cells, few red blood cells, and granular hyaline casts present. *Diagnosis.*—Retrocolonic abscess.

Operation.—Incision and drainage of large retroperitoneal hæmatoma. *Post-operative course.*—Barium enema showed an extracolonic mass to be pressing on the descending colon. A left pyelogram was typical of polycystic kidney. A right pyelogram showed the same diagnosis. Evidently, the left polycystic kidney had ruptured, resulting in a perirenal retrocolonic hæmatoma. The wound healed after two months. The patient was readmitted seven months later with oliguria and lumbar pain. He died in uræmia with pulmonary œdema.

At post-mortem he had huge bilateral polycystic kidneys, renal and ureteral calculi, left pyelo-ureteral stenosis. Cysts of the liver, hypertrophy of the left ventricle, pulmonary œdema, and bronchopneumonia.

Another case at post-mortem showed one of the cysts completely detached from the kidney, lying free about two inches from the lower pole in the perirenal tissue.

Infection.—This is probably the most important complication of polycystic kidney. Because infection threatens to increase the damage to an already impaired kidney, surgical procedures may be indicated. There are three main types of infection seen. In one type there is found pyelitis, pyelonephritis, or infected hydronephrosis, any of which may be secondary to moderate obstruction at the pyelo-ureteral junction by the pressure of cysts. There may be associated calculi. A second type is purulent infection localized to individual cysts. This is sometimes seen as a complication of blood-stream infection from some other focus, *e.g.*, general sepsis, and was found at post-mortem in one case of this group. A third type is a diffuse purulent infection of the residual renal parenchyma as well as the cysts with occasional complicating perforation and perinephric abscess. (Fig. 2.) Fifty per cent. of the cases showed some degree of mild infection as determined by the urinary findings while 32 per cent. showed definite pus in the urine. Out of 212 post-mortem cases, Sieber[26] found twenty-one with

purulent conditions of the kidney. Of the cases in this study, four patients were operated solely because of infection, two of which were for perinephric abscess.

Malignancy of the Kidney Complicating Polycystic Kidney Disease.—No

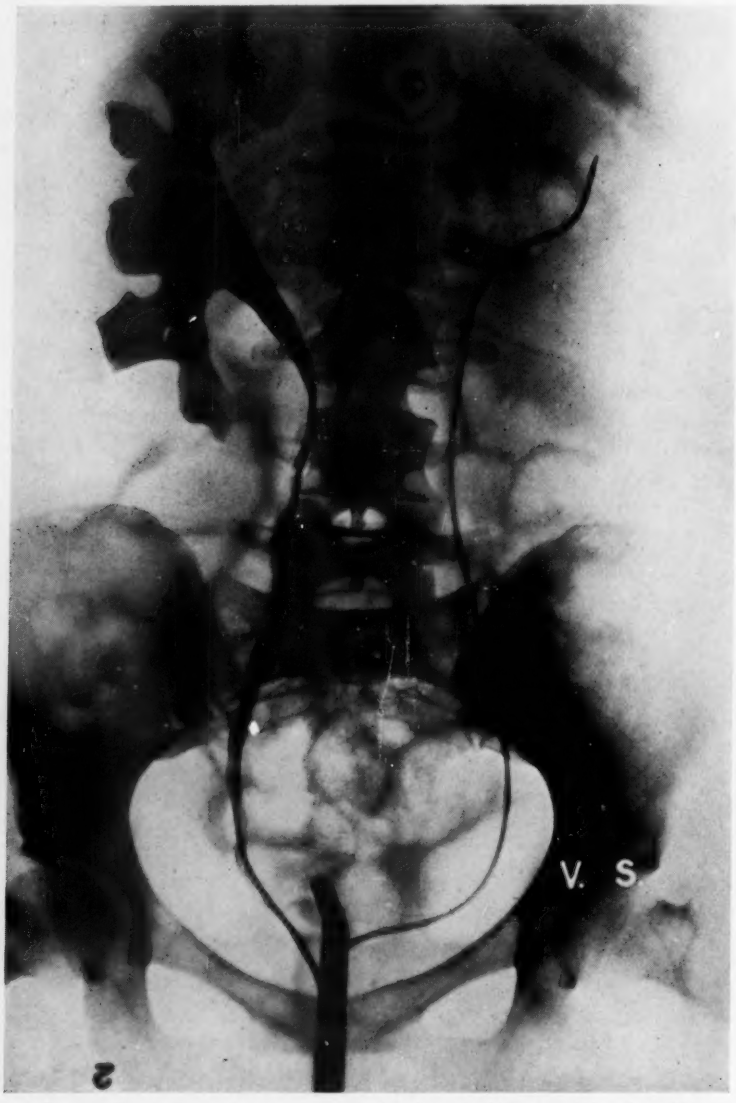

FIG. 2.—Pyelogram of case of bilateral polycystic kidneys. The right kidney was infected. There was an abscess at upper pole with perforation and perinephric abscess.

such cases were seen either clinically or pathologically in this hospital nor were any reports encountered in the literature.*

Renal Tuberculosis Complicating Polycystic Kidney Disease.—This was

* Since this article was accepted for publication, Walters and Braasch (Surg., Gynec. and Obst., vol. 58, No. 3, p. 649, March, 1934) mention three cases of polycystic kidney complicated by malignant disease which were nephrectomized.

not encountered in this series. Uteau,[65] Vintici,[66] and Chauvin and Tristant[67] have recently reported such cases.

Diagnosis and Differential Diagnosis.—In typical instances the diagnosis of congenital polycystic kidney is relatively simple. A history of loin or abdominal pain, hæmaturia, nocturia, and loss in weight in a patient who has unilateral or bilateral loin masses together with hypertension, and laboratory evidences of renal impairment, is most probable evidence of this disease. A familial history is confirmatory and a pyelogram will invariably prove the diagnosis. On the other hand, sometimes the diagnosis may be obscure and not made during life. This is especially true for cases who are admitted acutely ill or in extremis, or in traumatic cases. Four cases were first discovered on the post-mortem table. They are as follows:

CASE VII.—Forty-three-year-old man; had a carbuncle of the neck; crucial incision. Developed streptococcus hemolyticus sepsis and died.

Post-mortem.—Septicopyæmia, acute bacterial endocarditis, small bilateral polycystic kidneys with suppuration.

CASE VIII.—Fifty-seven-year-old man. Admitted with signs of left lobar pneumonia and cardiac insufficiency. History of hypertension and asthma for two years. Only the enlarged liver was palpable.

Post-mortem.—Moderately enlarged, bilateral polycystic kidneys with a staghorn calculus on one side; liver enlarged and nutmeg; pneumonia, left lung.

CASE IX.—Forty-eight-year-old woman; thought to be a hypertensive cardio-nephritic; died in uræmia; no abdominal masses except palpable liver. Abdominal X-ray was unsatisfactory.

Post-mortem.—Bilateral polycystic kidneys, cardiac hypertrophy, and coronary sclerosis.

CASE X.—Sixty-five-year-old male; had signs of pneumonia and died on the day of admission in coma and collapse.

Post-mortem.—Bronchopneumonia both lower lobes; generalized arteriosclerosis and bilateral polycystic kidneys.

Case IX represents a difficult type to diagnose. When a patient with signs and symptoms of hypertensive cardio-nephritic disease has a unilateral or bilateral lumbar mass, polycystic disease should be suspected. A retrograde pyelogram with a non-irritating solution will clear up the diagnosis.

Renal neoplasm is often justly suspected in these cases. A unilateral renal mass with subjective pain, hæmaturia, and loss in weight is common to both conditions. When a pyelogram of the affected side gives equivocal results, a pyelogram of the opposite kidney will usually settle the diagnosis. However, if this does not show indisputable evidences of polycystic kidney, an exploration must be performed. This was done in four cases.

Unilateral or bilateral hydronephroses or pyonephroses may simulate polycystic kidneys especially with the presence of palpable kidneys, lumbar pain, and evidences of renal insufficiency. Pyelographic studies should make the differential diagnosis. An infected polycystic kidney with a perinephric abscess may so closely resemble a pyonephrosis with perforation that operation may be the only means of recognition of the condition. However, a pyelogram of the opposite side will usually indicate the true condition.

A large spleen, or liver, or echinococcus cyst of the kidney may give

rise to the suspicion of polycystic disease but again pyelography will aid in the diagnosis.

Calculi because of their frequency in this disease may be misleading. This is especially true when dendritic calculi are present or when a ureteral stone blocks the ureter on the side of a unilaterally enlarged kidney. In this situation, as happened in this series, pyelographic study of the affected kidney was not possible or satisfactory and the diagnosis was not suspected.

Causes of Death, Post-mortem Studies and Pathogenesis.—Thirteen cases died without post-mortem examination. Clinically, nine of these died in uræmia. This was complicated in one case by cardiac failure, in another by pneumonia, and in a third by severe anæmia due to hæmaturia. Of thirteen adult cases that were necropsied, nine died in uræmia, two died because of pneumonia, one from a septicopyæmia, and one from intestinal obstruction. Six of the cases showed pneumonia at post-mortem, seven had ventricular hypertrophy, and four showed coronary sclerosis. Chronic passive congestion of the visceral organs was present three times.

A detailed gross and microscopical description of polycystic kidneys is not necessary at this time since several excellent descriptions are available and review of this material has added nothing new. For the same reason, the pathogenesis, with its numerous theories, will be summarized very briefly.

Of the older theories, it might be mentioned that Virchow thought that obstruction of the tubules due either to uric acid and lime deposits or inflammatory changes at the papillæ led to cystic development. Brigidi and Severi[68] believed that the condition was neoplastic based on the presence of epithelial nests and papillary proliferations in the cysts. Shattock[69] believed that the cysts developed from cells of Wolffian body remnants. However, the congenital nature of the condition is now well established.

The most generally accepted theory of imperfect development is that founded on the dualistic theory of renal genesis. (Kupfer.[70]) This explains cystic formation as the result of non-union of collecting and of secretory elements which arise from two separate anlagen. This theory was suggested by Koster[71] and developed further by Hildebrand,[72] and Ribbert.[73] Recently, Beeson[74] has attempted to explain this failure of union as the result of a relative poverty of secretory nephrogenic tissue with an atypical growth of the more abundant tubular collecting and vascular elements.

Kampmeier[9] believes that cysts develop from a persistence of normally occurring physiological cystic tubules which arise in fœtal life. Davis[75] assumes that polycystic kidney results from a delay in development and differentiation with subsequent cystic changes caused by an inherited defective protoplasm.

Operative Results.—Twenty-three cases (39 per cent.) were operated upon either in this hospital or at other institutions prior to or subsequent to our observation. Two cases had two operations each. The majority of these cases had multiple punctures of cysts and decapsulation with or without

other procedures. There were four post-operative deaths out of twenty-five operations, or a mortality of 16 per cent. Eight cases had no follow-up record; three cases died within one year after operation, while eight cases lived from one to fourteen years post-operatively.

One case was nephrectomized for polycystic kidney and was alive fourteen years afterwards. One case in which a retroperitoneal hæmatoma was evacuated, and one case explored in which a retroperitoneal sarcoma was found are described earlier in this paper.

Four patients had simple exploratory laparotomy for abdominal masses; nothing was done to the polycystic kidneys which were found. There was no mortality or follow-up.

Four patients had lumbar explorations for suspected renal neoplasm. Decapsulation and puncture of multiple cysts were performed. One patient died following operation; two were not followed and one was alive after eight years.

Three patients were operated upon primarily for complicating calculi. Multiple puncture of cysts was done. There was no mortality. One died from intestinal obstruction three months after leaving the hospital, and in two the follow-up data were incomplete.

Four patients were operated upon because of complicating infection. One of the earlier cases had a nephrectomy for pyelonephritis with multiple abscesses and died. Another case with an infected hydronephrosis, cortical abscesses, and perinephric abscess died following incision and drainage with nephrotomy. A third case had nephrotomy and drainage for pyonephrosis, multiple abscesses, and perinephric abscess on one side followed by a drainage operation on the other side two years later. This patient is well four years after the original operation. Another case is well one year following a nephrotomy and decapsulation.

Of five other operative cases, one was operated upon because of the insistence of the patient's family. This patient had been operated upon two years before with some beneficial result. He was uræmic, and the second kidney was subjected to multiple punctures following which he died. Two cases with punctures of many cysts were alive six months and two years post-operatively. Of two cases that had a nephrotomy and drainage, one died after two months and the other after thirteen years. The cause of death in both cases was uræmia.

Judged by the literature, it would seem that operative procedures in this condition have a high mortality. Brin[76] reported 117 nephrectomies with a 29 per cent. mortality and twenty-two nephrotomies with a 31.8 per cent. mortality. Mikaniewski[77] calculated 30 per cent. deaths in 127 nephrectomies and 45 per cent mortality in twenty-seven nephrotomies.

From our observations, it would seem that when very marked renal impairment with uræmia occurs, decapsulation and evacuation of cysts by puncture do not help. On the other hand, when renal impairment with nitrogenous retention occurs, mainly the result of superimposed infection,

a drainage operation may be of value if the infection subsides, provided there is enough functionating renal tissue present to carry on life.

Treatment.—As indicated earlier, the treatment of polycystic kidney disease must be conservative. The same medical treatment should be advised that is given to any chronic nephropathy irrespective of the cause. This includes rest, avoidance of physical or mental stress or exposure to infection, and dietetic regulations which have for their aim the prevention of any overloading of function or irritation of a diseased kidney.

Where pyelitis or pyelonephritis complicates the condition, catheter drainage and pelvic lavage with weak silver solutions may be tried with advantage.

In general, renal operations of any kind are emphatically contra-indicated. This applies to decapsulation, Rovsing's[78] puncture and evacuation of cysts, Payr's[79] ignipuncture of cysts, nephrotomy and nephrectomy. It must be remembered that these patients are often living on a minimum of renal tissue and anything, such as an operation, which may disturb the delicate balance is extremely risky.

There are times, however, when surgical procedures are indicated and are even life-saving. Exploratory operations for suspected renal neoplasm will be performed in a number of cases in spite of the most careful diagnostic procedures. In this situation, Rovsing's multiple punctures should be carried out because of the marked diminution in the size of the kidney which results. Theoretically, this diminishes the intrarenal pressure, although the benefit which actually results is questionable, and also diminishes the pressure against extrarenal organs. The latter point was well demonstrated in two instances. In one case, gall-bladder colic was probably caused by a cyst in the right kidney pressing against the junction of the cystic and common ducts and was relieved by puncture of the cysts. A second case with symptoms of marked duodenal pressure was relieved following puncture.

When diffuse suppuration, perhaps with perinephric abscess, occurs with persistently high temperature, elevation of blood-nitrogen figures, and a progressive down-hill course, operation must be performed. A simple drainage, often with nephrotomy, is indicated. A badly infected hydronephrosis with the same accompanying signs and symptoms may also require operation.

Calculous complications may require surgical intervention as when a stone blocks the ureter or a pelvic stone obstructs the pyelo-ureteral junction and conservative cystoscopic measures have failed. Surgery should not be employed in other stone cases.

Nephrectomy should never be done except possibly in cases of persistent suppuration in which other surgical procedures have failed and death may result from continued infection.

An occasional case may occur where the pressure of the enlarged kidney will give symptoms that make life unbearable. These cases can be relieved by multiple punctures and evacuation of cysts. Undoubtedly the change in intrarenal pressure resulting from such an evacuation may be detrimental by disturbing the internal renal balance of pressure relationships. These

studies have shown that patients without complication live longer without operation than those who have been operated upon.

Only occasionally will persistent loss of blood in the urine endanger the patient's life. Most cases will respond to rest, or transfusion, and, sometimes, pelvic lavage with astringent solutions. Hypertensive subjects will probably be benefited at times by the loss of blood. In the rare cases of severe bleeding, operation with multiple punctures may be advised.

The prevention of this disease would appear to be dependent upon the avoidance of progeny in cases with a familial history. Certainly, in a family, as reported by Fuller[80] where cases occurred in four generations and affected nine out of twenty-seven individuals, the bearing of children should be discouraged.

Summary.—An anatomical definition of polycystic kidney is given. While for practical purposes the disease may always be considered bilateral, two proved unilateral cases are described. Evidence is presented to show that the disease as seen in the newborn and in adults is the same condition. The study is based on one infant case and fifty-nine adults. The average age at the onset of symptoms is 41.5 years while the average age at death is fifty years. Forty-three per cent. of the cases are dead. The familial and hereditary nature of this congenital condition is emphasized. The symptoms presented serve to divide the cases into eight main clinical groups. The most common symptoms are loin and abdominal pain, hæmaturia (56 per cent.), nocturia, loss in weight, vomiting and tumor mass. Both kidneys were palpated in 66 per cent. of the cases. The liver was enlarged in 25.4 per cent. of the cases while liver cysts were present in 28.5 per cent. of the post-mortem examinations. The heart was enlarged in 30.5 per cent. and arteriosclerosis was present in 23.7 per cent. of the cases. The frequency of ocular fundus changes is noted. Laboratory evidence showed 71 per cent. of the cases to have renal impairment at one time or another. Fifty-seven per cent. of the cases had hypertension. Its relation to renal impairment is discussed. An associated anæmia with a relatively high color index is found. An unusually high percentage of calculi (23.7 per cent.) complicated these cases. Urinary findings indicate that severe infection was present in 32 per cent. of the cases. The use of non-irritating solutions for retrograde pyelography is advised. The diagnosis and differential diagnosis are discussed. The treatment is conservative, medical. Operation should never be done except for complications, as diffuse suppuration, certain calculous conditions, and for other rare indications which are detailed.

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POST-OPERATIVE WOUND COMPLICATIONS

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In any surgical clinic wound complications occur from time to time to impede the post-operative course of the convalescent patient. Fortunately, the majority of these complications are of minor importance, responding promptly to therapy. There is, however, a smaller group of patients who, following apparently clean surgical procedures, develop a post-operative wound complication of major importance, amounting almost to a catastrophe in certain instances. There are few surgeons of experience who cannot recall such examples in their own practice.

The incidence of imperfect wounds in any surgical clinic can be ascertained only by carefully analyzing the results in all cases operated upon over a period of years. With this in mind, we have undertaken a detailed study of all the wound complications which have occurred on Surgical Service "C" at the Hospital of the University of Pennsylvania during an eleven-year period extending from September, 1922, to September, 1933.

On this service every wound is classified at the time of the patient's discharge from the hospital. Imperfect wounds are graded as Types "A," "B" and "C." Type "A" represents serum collections or minor hæmatomata which do not delay convalescence or in any way interfere with the end-result of the patient's wound. Type "B" signifies the development of a definite wound infection which does not permanently interfere with the integrity of the wound or materially delay convalescence. Type "C" is reserved for cases of wound rupture or wound infection which impair the end-result or lead to the death of the patient.

In the past eleven years, 9,155 general surgical procedures have been carried out on Service "C." During this period of time 351 imperfect wounds have been observed, a general incidence of 3.81 per cent. In the accompanying table a tabulation of the incidence of the various complications is given. (Table I.)

In undertaking this study it was the purpose to analyze the various groups of wound complications encountered in an effort to better appreciate their incidence, the etiological factors contributing to their production, the optimal methods of treatment and the end-results in each series of cases.

A review of the literature indicates that imperfect wounds occur in approximately 10 per cent. of all clean cases. Carraway[1] reports 10 per cent., McKim[2] 8 per cent, Goff[3] 12.1 per cent., Roberts and Roberts[4] 12.8 per cent.,

TABLE I

Wound Complications

Service "C." September, 1922—September, 1933
Series of 9,155 Surgical Procedures

Type of Complication	Number	Per Cent.	Incidence, Per Cent.
Type "A"	248	70.6	2.70
Type "B"	65	18.7	.7
Type "C"			
(*a*) Infection	13	3.7	.14
(*b*) Wound rupture	25	7.1	.27
	351	100.0	3.81

Thorek[5] 7.17 per cent., Coley[6] 12.8 per cent. and MacFarlane[7] 7 per cent. In this day of aseptic surgery with rigorous pre-operative preparation of the surgical field and highly developed technic of closure and post-operative care, the high incidence of wound complications in the various surgical clinics is striking.

Type "A" Wound Complications.—The occurrence of serum collections in clean wounds has presented a problem since the advent of modern surgery. These collections are considered to be the result of trauma to the subcutaneous tissue at operation, either from rough handling of the tissues, careless ligation of superficial vessels, rough use of retractors or undue tension exerted by stay or tension sutures. As would be expected, serum collections are especially prone to appear in incisions made through fat abdominal walls. In Table II a tabulation of the incidence of this complication is given:

TABLE II

Type "A" Wound Complications

Surgical Condition	Number of Operations	Number of "A" Comps.	Inc. Comp., Per Cent.
Appendicitis	1,216	68	5.59
Inguinal hernia	749	65	8.67
Duodenal ulcer	207	36	17.39
Gall-bladder disease	490	15	3.06
Gastric lesions	95	13	13.68
Lesions of bone and joints	—	13	—
Femoral and incisional hernia	—	12	—
Diagnostic laparotomies	—	10	—
Breast lesions	—	7	—
Lesions of extremities	—	6	—
Pelvic lesions	—	3	—
Totals	9,155	248	2.70

This group of cases was much the largest of the three, comprising 70.6 per cent. of the entire series of imperfect wounds. It includes only cases in which a sterile serum collection or a minor hæmatoma developed. This complication is especially prone to develop following certain abdominal incisions. The accompanying table (Table II) shows that the highest incidence occurred

following operations for gastric and duodenal ulcer, in which either a paramedian or upper mid-line incision was employed, the wounds being closed without drainage. Inguinal hernia were next in order and appendectomy incisions third. The relatively low incidence of serum collections in gall-bladder patients who are notoriously obese is probably explained by the fact that these cases were invariably drained and an avenue was thus provided for the continual escape of serum during the early post-operative period.

Serum collections in this series characteristically make their appearance from the fifth to the eighth post-operative day, soon after removal of the skin sutures. A low-grade temperature ranging from 99 to 99.4 during this period calls for a careful examination of the patient's incision. Quite frequently an area of superficial or deep softening can be demonstrated on palpation. Not infrequently these collections present as small dark blue or brown blebs in the line of the incision which will rupture spontaneously with the discharge of clear yellow serum if not opened surgically. On introducing a sterile probe a variable amount of fluid escapes and may continue to drain for a period of several days. Unless the pocket becomes secondarily infected with skin organisms, it progresses rapidly to complete healing with no deleterious effects on the patient's wound or convalescence. In this series no permanent impairment of a wound could be attributed to this complication.

Type "B" Wound Complications.—The imperfect wounds classified as Type B form a much more important group. These cases developed frank wound infections but there was no permanent effect upon the wound or material delay in the patient's period of hospitalization. In Table III the various operative procedures which were followed by this type of wound complication are listed.

TABLE III

Type "B" Wound Complications

Surgical Condition	Number of Cases
Inguinal hernia	11
Acute appendicitis	9
Duodenal ulcer	7
Gall-bladder disease	7
Breast tumors	4
Operations on extremities (2 were clean bone cases)	6
Carcinoma of stomach	4
Operations on colon and rectum (Ca)	3
Femoral and incisional hernia	3
Chronic appendicitis	4
Operations on genito-urinary tract	3
Tuberculous peritonitis	1
Thyroid disease	1
Operations on small bowel (obstruction)	1
Operations for relief of ascites	1
	65

NOTE.—Of sixty-five cases, sixty-four recovered. Infection was a contributing factor in the death of the fatal case.

The many sources of contamination of the surgical wound from the time of incision to complete healing have been repeatedly enumerated by the various authors discussing the subject of imperfect surgical wounds. The fact remains that in the vast majority of cases pathogenical organisms gain access to the wound by implantation, either from the outside at the time of operation, from septic material at the time of operation or from faulty technic during the post-operative care of the wound.

The sterilization of drapes, instruments, suture material and gloves has reached that degree of perfection where it is rarely possible to trace a wound infection to one of these sources. There is not quite such an unanimity of opinion regarding the correct method of preparing the surgical field. Different antiseptics have come into favor and disappeared into oblivion as their shortcomings have been demonstrated. A thorough cleansing of the patient's skin with soap and warm water prior to operation followed by the single application of one of the standard antiseptics is now accepted as an adequate procedure to obtain a sufficiently sterile operative field. On Surgical Service "C" mercurochrome compound has been employed as the skin antiseptic during recent years, with very satisfactory results.

Meleney and Stevens[8] have called attention to the rôle played by streptococcic carriers in the production of wound infections. In investigating a series of streptococcic infections developing within a short period of time, these authors found that one-third of the operating personnel were harboring the hæmolytic streptococcus in their throats. These authors suggest that both the nose and mouth of all the operating team be adequately covered to protect against this source of wound contamination.

It is well recognized that various refinements in operative technic may do much to reduce superficial wound infections. The frequency with which a scalpel may carry organisms from the skin into the deeper layers of the wound has been referred to by Sutton,[9] Thorek,[5] Cox,[10] Van Alstyne[11] and Carraway.[1] The latter author cultured a series of 562 blades used to make the skin incisions and found that 117 or 20 per cent. of them showed a positive culture.

The effect of mass ligature of fat and the use of excessive amounts of catgut in the subcutaneous tissue have been referred to by Bowman,[12] Goff,[13] Carstens,[13] and Cutting,[14] Cabot[15] and others. Keith[16] and Carstens[13] both recommend the use of narrow strips of flamed adhesive tape to obtain coaptation of the skin and subcutaneous tissue in abdominal incisions in an effort to eliminate entirely subcutaneous and skin sutures.

Recently, on Surgical Service "C," a special effort has been made to limit the amount of catgut used in the subcutaneous tissues. All small bleeding vessels have been ligated with a single tie of No. 0 plain catgut, using flat knots only on larger vessels. The use of a subcutaneous stitch for approximation of this layer has been largely obviated by employing a deeply placed vertical mattress suture of silk for the closure of the skin and subcutaneous tissues. The results have been very gratifying since the adoption of this technic.

It is generally accepted that the abdominal wall is less able to cope with infection than the peritoneal cavity. Royster[17] and McKim[2] have recently called attention to the frequency of wound infections following removal of gangrenous non-ruptured appendices. To reduce this incidence of wound infections in cases in which septic material is handled, McKim recommends the application of "bipp" at the time of operation while Thorek[5] and MacFarlane[7] both recommend the use of half strength tincture of iodine in similar cases. We have recently employed 2 per cent. aqueous mercurochrome in such instances with gratifying results.

Roberts and Roberts[4] and Valdes[19] have recently reported their results in treating clean abdominal incisions by the open method without dressings. They report their incidence of perfect wounds as 87 per cent. and 94 per cent. respectively, although both series of cases were small. While there are certain attractive features in the method they outlined, it is unlikely that it will ever be widely employed because of its obvious disadvantages.

Du Mortier[18] in an excellent paper has shown that the surgical wound is most susceptible to post-operative infection during the first six hours after closure. After this period the wound is progressively less susceptible to infection. He was unable to demonstrate any decrease in the resistance of the wound to infection on the fifth or sixth day when the skin sutures are removed.

An analysis of our own series of Type "B" wound infections shows that over 56 per cent. of the infections made their appearance before the sixth post-operative day. In Table IV a tabulation of the cases and their time of appearance is shown.

TABLE IV

Time of Appearance of "B" Wound Infections

(Day of Convalescence)

Day Infection Appeared	Number of Cases	Per Cent. Cases
Second day	8	12.3
Third day	5	7.6
Fourth day	11	16.8
Fifth day	13	19.8
Sixth day	4	6.1
Seventh day	5	7.6
Eighth–sixteenth days	14	21.4
Sixteenth day on	1	1.5
Day not noted	4	6.1
Totals	65	100.0

A study of the histories of these sixty-five cases discloses the fact that in fourteen or 21.5 per cent. a possible source of contamination of the wound was determined. In three cases the wounds were contaminated with the patient's excreta, in four a hæmatoma in the wound became secondarily infected while in the remaining seven cases the abdominal wound was contaminated at operation by the pathological material handled at that time. It is

interesting to note that the infection in five of the above-mentioned cases followed the removal of non-ruptured gangrenous appendices in which it was not felt necessary to drain the peritoneal cavity.

In this series of sixty-five cases, general anæsthesia was employed in forty-seven and local in eighteen instances. The tendency of local anæsthesia to predispose to wound infections has received little attention, yet nine of the fourteen hernias listed in this series were operated under novocaine anæsthesia. Realizing that herniorrhaphy incisions are particularly prone to become superficially infected, one wonders whether local anæsthesia, which is so commonly employed in these cases, may serve as a predisposing factor by lowering the resistance of the tissues about the operative site.

Positive cultures were obtained in twenty-six of the group, the organisms found being listed in Table V.

TABLE V

Type "B" Wound Infections

Report of Cultures Taken from Infections of "B" Wounds

Organism	Number of Cases
B. coli	8
Staphylococcus aureus	7
Staphylococcus albus	7
Hæmolyticus streptococcus	3
B. mucosus capsulatis	1
	26

NOTE.—No report on cultures taken in thirty-nine cases.

In the remaining thirty-nine cases cultures either were negative or were not taken. As might be expected, the staphylococcus and *Bacillus coli* were much the most common offenders.

All wounds which developed the signs of infection were treated promptly but conservatively. If an area of redness was seen about one or more of the skin sutures, simple section of the suture was promptly done, leaving the suture in place. Hot wet dressings were then applied continuously and in many instances the signs of infection disappeared in from one to two days. If the appearance of the wound was not definitely improved the second day, the skin sutures were removed and the wound edges sufficiently separated to provide ample drainage. Hot wet dressings were then continued. Repeated irrigations of the infected wound were strictly avoided since such therapy interferes with, rather than aids, nature's protective efforts.

We have had no experience with the closed method of treating infected surgical incisions as advocated by Watkins,[20, 21, 22] and by Miller.[23] These authors permit the skin sutures to remain and apply moist boric acid dressings until healing occurs. Although the tendency of undrained pus to burrow and destroy underlying fascial planes is well recognized, excellent success as

far as wound healing and end-results are attributed to the closed method of treatment. It would seem that one of the basic principles of surgery is being violated, that of adequate drainage in the presence of infection.

That these so-called minor wound infections represent a real economic problem as well as an unfortunate post-operative surgical complication is not generally recognized. In this series of sixty-five cases, there was a delay of 439 hospital days in convalescence, an average of 6.75 days per patient. Stated differently, every complication of this type occurring in a ward patient cost the individual, the hospital or the state approximately $27.00, the cost per private patient being proportionately higher.

Fortunately superficial infections of this type have little permanent effect upon the integrity of the patient's wound. In this group of sixty-five cases, post-operative hernia attributable to the wound infection developed in only four cases, an incidence of 6.1 per cent. In more serious and extensive infections, the incidence would unquestionably be higher. Boyle[24] states that post-operative hernia will follow in from 40 per cent. to 80 per cent. of those cases operated through rectus incisions in which a suppurative process develops and persists for over two weeks.

Type "C" Wound Complications.—Classified as Type "C" wound complications are those cases of wound rupture and grave wound infections which lead either to an impaired surgical result or death of the patient.

Thirteen cases of serious wound infection were observed in this study. In Table VI the types of surgical procedures followed by this complication are listed.

TABLE VI

Classification of Type "C" Infections

Type of Operation	Number of Cases	Lived	Died
Operations on lower extremities			
(*a*) Amputation diabetic gangrene	4	2	2
(*b*) Amputation traumatic gangrene	1	1	—
(*c*) Amputation carcinoma of leg	1	1	—
(*d*) Fracture of patella	1	1	—
Operations on biliary tract	2	1	1
Carcinoma of stomach	1	0	1
Inguinal hernia	2	2	—
Appendicitis	1	1	—
	13	9 (69.2%)	4 (30.8%)

Operations on the extremities comprise over 50 per cent. of this group and of these, operations for diabetic gangrene were the most common. The striking tendency of serious infection to develop in the amputation stump of the diabetic patient has been recently stressed by one of us.[25] Although pus was not present at the time of operation in any of the thirteen cases, drainage was instituted in five instances. In Table VII the organisms responsible for the wound infections are noted.

TABLE VII

Type "C" Infections. Organisms Found

Organism	Number of Cases	Lived	Died
Staphylococcus	5	3	2
Hæmolyticus streptococcus	1	1	0
B. welchii	1	1	0
Anærobic organism (not gas)	1	1	0
Colon and streptococcus	2	1	1
Totals	10	7	3

NOTE.—Type of organism not noted in three cases.

In each of the thirteen cases the wounds were treated by immediate removal of all skin sutures and wide separation of the wound edges. Dakinization was instituted in three instances in which an oxidizing agent was indicated to combat an anaërobic infection.

There were four deaths in this group of thirteen cases, a mortality of 30.8 per cent. In three instances the fatal outcome was partially attributable to the wound infection while in the fourth case, which died with a general peritonitis, it was felt that the peritoneal infection was secondary to the imperfect wound.

The average number of hospital days for those cases which survived the wound infection was fifty. The average length of life of the four fatal cases was 17.5 days following operation.

Post-operative Rupture of Surgical Wounds.—The subject of post-operative rupture of the surgical wound is one of great importance to everyone interested in surgery. This complication, when it occurs, presents a serious problem in the post-operative management of the patient.

Starr and Nason[26] state that this complication occurred in .61 per cent. of their cases following laparotomy. Finche[27] reports an incidence of 1.1 per cent., Meleney and Howes[28] 1-2 per cent., Colp[29] .9 per cent. and Horner[30] .29 per cent. in a series of 1,010 cases of cæsarean section. In our own series of 9,155 cases we have observed this complication twenty-five times, an incidence of .27 per cent. Madelung[31] states that wound rupture occurs three times as commonly in women as in men. This does not agree with our experience since only six cases, or 24 per cent., of our series have been females.

Many contributing factors have been suggested as possible causes of wound rupture. These may be summarized as follows:

(1) Improper closure of the abdominal incision; that is, inadequate hæmostasis, failure to securely suture the peritoneum, failure to approximate the fascial layers and the use of excessive suture material in the various planes of closure.

(2) Too early discontinuation of the anæsthetic on the table with straining before all the fascial planes are closed.

(3) Overenergetic use of carbon dioxide during the final moments of the operation to prevent post-operative atelectasis.

(4) Unusual strains upon the incision during the early post-operative period from protracted vomiting, marked distention, epilepsy, delirium tremens, post-operative psychosis or post-operative pulmonary complications associated with excessive coughing.

(5) Early dissolution of suture material in non-infected cases due to defective catgut.

(6) Wound infections with resultant dissolution of suture material.

(7) Age, debility and the cachexia of neoplastic disease with retardation of the healing process.

It has been repeatedly observed that operations upon the duodenum, stomach and biliary system are the ones most frequently followed by this complication. In the accompanying table (Table VIII), the type of lesion and the extent of the wound rupture in our own series of cases is shown.

TABLE VIII

Wound Rupture, Operations in Which Rupture Occurred

Type of Operation	Cases	Extent of Rupture			Number Died
		Fascia	Perit. and Fascia	Evisc.	
Duodenal and jejunal lesions	11	5	3	3	4
Liver, gall-bladder and pancreas	6	0	4	2	2
Gastric lesions	4	0	2	2	2
Colon and rectum	2	1	0	1	0
Appendix	1	0	1	0	0
Spleen	1	0	1	0	0
Totals	25	6	11	8	8

Operations on the duodenum and jejunum are seen to be most frequently complicated by wound rupture in this series, yet contrary to the reports from other clinics, only one of the eleven cases of duodenal ulcer listed was a perforated ulcer.

In nineteen cases of disruption, or 76 per cent., of the series, all layers of the abdominal wall were found to have separated, being associated with evisceration in eight cases. In the remaining six cases the peritoneum alone remained intact. As would be expected incisions in the upper abdomen were those most frequently affected. In Table IX the types of incisions followed by wound rupture are listed.

TABLE IX

Wound Rupture, Type of Incision

Upper abdomen	Number of Cases
(*a*) Right or left rectus	9
(*b*) Paramedian	6
(*c*) Mid-line	4
(*d*) Modified Kocher	3
Total	22 or 88 per cent.

TABLE IX—(*Continued*)

Lower abdomen	Number of Cases
(*a*) Mid-line	2
(*b*) Right or left rectus	1
(*c*) McBurney	0
Total	3 or 12 per cent.

The strength of different suture materials and the effect of wound infections upon sutures has been repeatedly discussed. Goff[3] has reported a lower incidence of wound infections in a series of clean cases closed with silk as contrasted with a control series closed with catgut. Howes and Harvey[32] have recently pointed out the dangers of using excessive catgut in abdominal wound closure and call attention to the fallacy of using excessively heavy catgut to insure firm closure. These authors have shown that the use of mattress catgut sutures to close the fascia only increases the strength of the suture from 10–20 per cent. and does not warrant the increased amount of catgut necessary. The use of strangulating through-and-through stay sutures was abandoned several years ago in our clinic with definite improvement in the healing of the surgical incision. Lahey[33] reports a similar experience.

The type of suture material used in this series of cases is shown in the accompanying table. (Table X.)

TABLE X

Ruptured Wounds, Type of Suture Material Used

Fascial Closure	Cases	Per Cent.
(*a*) Interruptedchromic No. "1"	21	84
(*b*) Interrupted iodine gut No. "2"	3	12
(*c*) Interrupted silk No. "12"	1	4
Silkworm gut stays plus chromic	4	16
Drainage employed (intraperitoneal)	8	32

NOTE.—Only three cases were soiled (pus or intestinal content) at the time of operation.

It is well known that any catgut used for wound closure acts as a foreign body and is associated with a certain amount of reaction. In the presence of infection it rapidly loses its strength and is absorbed regardless of chromatization. For these reasons, the use of fine silk for the closure of the fascia has been recently revived and we have been using it with very satisfactory results during the past six months.

A review of the post-operative course of this group of patients from the time of operation until the wound rupture occurred brought to light some very interesting findings. In only three instances was the immediate post-operative course listed as uneventful. In the remaining twenty-two cases (88 per cent.) there was some additional factor which served to make the patient's convalescence stormy. (Table XI.)

Post-operative pulmonary complications were present in nine, or 36 per cent., of these cases and the associated coughing exerted an undue strain upon the line of closure. Undue distention associated with excessive vomiting

TABLE XI

Ruptured Wounds, Associated Complications

Type of Complication	Cases
Post-operative pulmonary complications	
(*a*) Bronchitis	7
(*b*) Broncho-pneumonia	1
(*c*) Atelectasis	1
Distention associated with vomiting	7
Delirium (alcoholic and epilepsy)	4
Debility (extreme anæmia)	2
	22

NOTE.—Of the series of twenty-five cases only three were listed as uneventful until wound rupture occurred.

was a feature in seven cases while delirium was observed in four cases in the series. All of these factors we believe contributed definitely to the later development of the wound rupture. Stormy anæsthesia means stormy convalescence.

This complication usually makes its appearance from the fifth to the ninth post-operative day, soon after the removal of the skin sutures. It is during this period that the dissolution of suture material takes place, tension sutures are removed and other existing post-operative complications become well established.

In this series of twenty-five cases, 80 per cent. appeared from the fifth to the seventh post-operative days, no cases having developed after the eighth post-operative day.

Although wound disruption appears to develop rather suddenly from five to eight days after operation, it is probable that the deeper layers of the wound give way early in the post-operative course. Omentum is then forced into the peritoneal defect and serves to exert pressure upon the line of suture until complete rupture occurs.

Clinically these patients often continue to have abdominal discomfort after their third post-operative day. They remain distended after an enema, peristalsis is slightly hyperactive and hiccough and belching are frequent symptoms. Such a symptom complex should always lead one to inspect a deep wound rupture and to carefully observe the patient from this stand-point.

TABLE XII

Wound Rupture, Day Complication Occurred

Post-operative Day	Number of Cases	Per Cent.
Fourth	3	12
Fifth	5	20
Sixth	6	24
Seventh	9	36
Eighth	2	8
Totals	25	100

These clinical observations are quite in keeping with the experimental work of Du Mortier[18] and Howes, Sooy and Harvey[34] who have shown that fibroblastic proliferation in wounds develops rapidly about the sixth postoperative day with a marked increase in the strength of the wound after the preliminary "lag" period has passed.

Separation of the deeper layers of an incision may often be diagnosed by the presence of a slight fullness or bulging of the wound during the postoperative period even though the skin appears to be perfectly healed. Palpation of the incision with the gloved hand usually makes the diagnosis apparent and careful separation of the skin edges discloses the presence of omentum immediately beneath the skin.

More frequently, however, one's attention is called to this complication by the appearance of fresh blood upon the dressings later in the same day that the skin sutures are removed. Examination discloses the presence of a variable degree of separation of the skin, often with the abdominal content presenting between the wound edges.

Less frequently the patient may suddenly experience severe pain in the operative site while straining, retching or vomiting and complete rupture of the wound suddenly occurs without warning.

When wound rupture occurred, all the patients in the series were seen immediately and the wounds carefully examined.

TABLE XIII

Ruptured Wounds, Immediate Appearance of Wound

Findings on Examination	Cases	Per Cent.
Fascia separated	6	24
Peritoneum and fascia separated	11	44
Evisceration (gut in wound)	8	32
No suture material visible	7	28
Sutures visible, pulled out	3	12
Definite evidence of infection	6	24
Positive cultures obtained	4	16

The principal findings at the time of the primary examination are listed in the accompanying table. (Table XIII.) No suture material or even catgut knots could be found in seven of the cases and the wound disruption in these instances has been attributed to faulty suture material. This was further suggested by the fact that four of these cases were observed within a period of a few months with the same make gut. There was evidence of infection in only six of the twenty-five cases of wound rupture, positive cultures being obtained in four instances.

When wound rupture occurs the patient is a real surgical emergency and immediate treatment is necessary. Prompt secondary suture of the abdominal incision has been recommended as the most satisfactory method of treatment by Shipley,[35] Clute,[36] Holtermann,[37] Starr and Nason,[25] Horner,[30] and Lahey.[33] While local anæsthesia is the choice of most surgeons as the anæsthetic agent, Starr and Nason[26] favor the use of spinal in all cases in

which the condition of the patient warrants its use. Heavy silk, silkworm gut and silver wire are the suture materials most commonly employed. The stitches are usually of the interrupted type and are placed through the entire thickness of the abdominal wall. In those cases in which distention makes closure difficult or impossible, the performance of a simple enterostomy after the method of Witzel may be advantageous and often lifesaving.

Lahey,[33] and Starr and Nason[26] state that peritoneal infection following wound rupture is rare in their experience, a certain degree of peritoneal immunity apparently having developed by the time this complication makes its appearance. For this reason they advocate closing the wound completely without drainage.

In the experience of the senior author, immediate secondary suture of a ruptured wound has not proved to be the ideal method of handling these complications. Since the majority of these patients are desperately ill when the complication occurs, any operative procedure, no matter how simple it may be, is fraught with grave danger. For this reason, what appears to be a more rational and conservative method of treating these cases was adopted some years ago.

The method employed is not new but has recently been advocated by Clute[36] and others as a palliative method for desperately ill cases. The wound edges and the protruding viscera are first painted with 2 per cent. aqueous mercurochrome. The omentum and gut are then gently replaced down to the level of the parietal peritoneum. The skin edges are then closely approximated with narrow strips of flamed adhesive tape and a firm dressing is applied. The procedure is almost painless and no anæsthetic is required. This dressing is then left undisturbed for a period of five days, at which time the gauze packing may be replaced and the bottom of the wound will be seen covered with a layer of healthy granulation tissue. We believe the major advantages of this method to be its simplicity, omission of an anæsthetic, the speed with which it can be carried out and the fact that a certain degree of peritoneal drainage is provided. As soon as the patient has recovered from the immediate shock of the wound disruption and there is no evidence of infection in the wound, secondary suture may be performed with a much greater degree of safety, in those cases where it is deemed advisable.

Immediate secondary suture following rupture of a surgical wound is reserved for those cases which are not particularly ill when the complication occurred.

In Table XIV the various methods of treatment employed in this series of cases are given.

A review of the literature on the subject of ruptured wounds reveals a paucity of figures on the mortality associated with this complication. Horner[30] quotes the mortality in four German clinics following gynæcological surgery as follows: Sherer[38] 75 per cent. in a series of four cases, Holtermann[37] 47 per cent. in fifteen cases, Madelung[31] 22.3 per cent. and Erhardt[39] 20 per cent. Recently Meleney and Howes[28] have reported a mortality of 44 per cent. in

TABLE XIV

Wound Rupture, Treatment of the Complication

Form of Treatment	Number of Cases	Per Cent. Cases	Cases Lived	Per Cent. Cases Lived	Per Cent. Cases Died
Packed, adhesive strapping.....	15	60	10	66.6	33.3
Temporary strapping, later secondary suture.....	6	24	4	66.6	33.3
Immediate secondary suture.....	4	16	3	75.0	25.0
	25		17	68.0	32.0

fifty cases, Grace[40] 39 per cent. in forty-six cases and White[41] 53 per cent. in thirty cases.

In our own series of twenty-five cases, there were eight fatalities, an incidence of 32 per cent. In Table XV an analysis of the eight fatal cases is given.

TABLE XV

Wound Rupture, Analysis of Eight Fatal Cases

Type of Treatment	Number of Cases	Cause of Death Peritonitis	Cardiorenal	Shock
Packed and strapped.....	5	4	1	0
Temporary packing, secondary suture.....	2	1	0	1
Immediate secondary suture....	1	0	1	—
Totals.....	8	5 (62.5%)	2 (25%)	1 (12%)

It is evident that peritonitis was the major cause of death, being responsible for five of the eight cases. In only two of these five cases was a positive culture obtained from the wound at the time the wound rupture was first examined.

One of the major objections to the treatment of ruptured wounds by the method here outlined has been the high incidence of hernia following its use. It is indisputable that herniæ are more frequent with the adhesive tape method than with immediate secondary suture, but it is felt that the major problem in these cases is to get the patient safely over the immediate crisis with the least possible interference. Herniæ which develop may be subsequently repaired with comparative safety. Watkins[22] and Clute[36] state that they have seen no herniæ following secondary suture of ruptured wounds and Lahey[33] reports that few have occurred in his experience. We have not had as uniformly satisfactory results in preventing post-operative herniæ in the small group treated by immediate secondary suture.

Prolongation of the period of hospitalization has been suggested as another objection to the adhesive tape method of treatment. In the group of cases in this series that survived the complication, the average increase in hospital days was 11.2 days. This does not seem excessive when one considers the usual condition of the patient who develops a ruptured wound.

In Table XVI the follow-up findings in fourteen cases that returned for examination are listed.

TABLE XVI

Wound Rupture, Analysis of Follow-up Results in Fourteen Cases

Treatment	Number of Cases	Hernia		No Hernia
		Large	Small	
Packed and strapped.....	9	2	2	5 (55.5%
Secondary suture.....	5	1	0	4 (80.0%)
Totals.....	14	3	2	9 (64.2%)

NOTE.—Two cases are too recent to be accurately classified.

Of the five cases treated by immediate secondary suture one developed an incisional hernia. Of the nine cases treated by the adhesive tape method four developed incisional hernia. Although it seems surprising that the incidence of hernia is not higher following the adhesive tape method of treatment, similar results have been observed elsewhere. Starr and Nason[26] believe that the occurrence of hernia is entirely dependent upon the presence of sepsis at the time of the wound rupture but this can hardly be accepted in all cases. In none of the five cases in this series which developed hernia was infection a feature.

Summary and Conclusions.—In a series of 9,155 general surgical procedures, 351 imperfect wounds were observed, an incidence of 3.81 per cent. Type "A" wound complications were much the most common, comprising 70.6 per cent. of the entire group. Type "B" complications developed in sixty-five instances or 18.7 per cent. of the series. Type "C" wounds, which include the serious infections and cases of wound rupture, were encountered thirty-eight times or 10.8 per cent. of the group. Our study of these cases suggests the following conclusions:

(1) Reduction of the amount of catgut under the subcutaneous tissue has been the most important factor in reducing the incidence of serum collections.

(2) Contamination of the wound by infectious material handled at operation is one of the most frequent causes of superficial wound infection.

(3) Drainage of the superficial layers of all wounds in which soiled material is handled will materially reduce the incidence of Type "B" infections.

(4) "Wide open" drainage with adequate separation of the wound edges is the most logical and satisfactory method of handling a wound infection.

(5) No effort should be made to close amputation stumps following operations for infected diabetic gangrene in which pre-tibial œdema, extending halfway to the knee, is demonstrable.

(6) A definitely stormy post-operative course usually precedes the development of a wound rupture. This was true in 88 per cent. of our series of twenty-five cases.

(7) Wound disruption is usually observed between the fifth and eighth

post-operative days. Eighty per cent. of our series were diagnosed during this period.

(8) The treatment of ruptured wounds with packing and adhesive straps is the safest method for the patient.

(9) Peritonitis is the most common cause of death following wound disruption.

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ABDOMINAL-WALL DEFECTS FOLLOWING APPENDICECTOMY

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From time to time articles have appeared in the medical journals on the incidence of incisional herniæ following abdominal operations. In recent years, Bancroft,[1] Cave,[2] Fowler,[3] Garlock,[4] and others[5] have reported more specifically on series following operations for appendicitis. It seemed to us, however, in looking over these articles, that none of the statistics really gave the number of cases that were left with some defect of the abdominal wall. As will be shown in our charts, this number is much higher than if only the incisional herniæ are included. Our original intention had been to tabulate the defects following all the laparotomies done on our service at Bellevue Hospital during the past fifteen years. As this was found too vast and complicated an undertaking, we limited ourselves in this paper to an analysis of 700 appendicectomies, performed through an incision in the right lower quadrant. All were done by members of the interne and attending staff of our division and were followed for an average period of well over a year. No case was included that had been followed less than six months.

As we were primarily interested in the end-results only, no special attention was given to whether the case was acute or a chronic one. As can be surmised, the majority of the acute ones were the drained cases. Our figures, then, will show actually how many patients developed anything from an abdominal-wall weakness to a true incisional hernia either as a direct result of the operation or as a result of some complication or sequela. In the first five charts all the defects are grouped together. In the last two, an attempt is made, as far as it was possible, to subdivide them into their respective groups.

In the first chart (Chart I) the cases are grouped according to the incision, giving their respective number, the number of defects and the percentage in each group. The total then is given, which shows that eighty-three patients out of 700 or a little less than 12 per cent. had some weakness, either slight or marked, following the operation. Of course cases operated through a McBurney or a right rectus incision make up the largest number in a series of this kind. By coincidence there are thirty-eight defects in each group, but the percentage is higher in the split rectus group due to the fact that their total number was less. Some years past a transverse incision was used in some of the cases. It began at the anterior superior spine and ran upwards and inwards toward the umbilicus, the external oblique aponeurosis being split transversely. It was soon found that this incision was not practical as many incisional herniæ followed its use.

CHART I

Classification of Cases According to Incision and Their Defects

	Number	Defects	Percentage
McBurney	386	38	9.8
Right rectus	250	38	15.2
Kammerer	20	1	5.0
Reverse Kammerer	18	0	0.0
Transverse	20	5	25.0
McBurney c Weir ext.	5	1	20.0
Transverse c Weir ext.	1	0	0.0
Totals	700	83	11.8

In the second chart (Chart II) the cases are grouped according to whether clean, drained or infected. The clean group were those that were not drained and healed by primary union. The drained ones were those that had some form of drainage at the original operation and the infected ones were those that had no drain inserted but broke down some time later. As was to be expected, the drained cases had the largest percentage of defects while the infected ones had a fair proportion also. The drained split-rectus group had the highest individual percentage, approximately 31 per cent. It may be noted in passing that the Kammerer and reverse Kammerer incisions had no defects in the clean group and only one in the drained. However, there are not enough cases to make a fair comparison.

CHART II

Classification of Cases, Whether Clean, Drained or Infected

	Number	Defects	Percentage
Clean Cases			
McBurney	196	5	2.5
McBurney c Weir ext.	3	0	0.0
Right rectus	128	4	3.1
Kammerer	18	0	0.0
Reverse Kammerer	15	0	0.0
Transverse	10	1	10.0
Total clean cases	370	10	2.7
Drained Cases			
McBurney	166	31	18.6
McBurney c Weir ext.	2	1	50.0
Right rectus	90	28	31.1
Kammerer	2	1	50.0
Reverse Kammerer	3	0	0.0
Transverse	7	2	28.0
Transverse c Weir ext.	1	0	0.0
Total drained cases	271	63	23.2
Infected Cases			
McBurney	24	2	8.3
Right rectus	32	6	18.7
Transverse	3	2	66.6
Total infected cases	59	10	16.9

In the third chart (Chart III) a comparative analysis is tabulated between the split rectus and McBurney groups. For simplicity the cases are divided into two divisions, one the clean and the other the drained and infected together. At the same time they are also grouped according to their sex. It is well demonstrated that there are more defects following a split rectus operation than after an intermuscular one. Also that no matter how the cases are grouped, male patients develop about twice as many defects as the female.

CHART III

Classification According to Sex for the McBurney and Rectus Incisions

	Number	Defects	Percentage
Male Patients			
McBurney:			
Clean	125	4	3.5
Drained and inf.	160	29	18.1
	285	33	10.9
Rectus:			
Clean	46	2	4.3
Drained and inf.	59	22	37.2
	105	24	22.8
All Male Patients	390	57	14.6
Female Patients			
McBurney:			
Clean	71	1	1.4
Drained and inf.	30	4	13.3
	101	5	4.9
Rectus:			
Clean	82	2	2.4
Drained and inf.	63	12	19.0
	145	14	9.7
All Female Patients	246	19	7.6

In the fourth chart (Chart IV) an analysis is given of all the cases that had a pulmonary complication or developed one after the operation. There were two patients with fairly active tuberculosis operated on who did not develop any defect. In going over all the histories carefully it seemed to us that in only two cases the pulmonary condition had any bearing. One was a case of persistent bronchitis and the other a sixty-year-old cardio-asthmatic. Both of these we believe developed their defect as a direct result of their chronic cough.

The fifth chart (Chart V) is an analysis of three small but interesting groups. The first one includes ten cases that were not sutured or had only one or two stitches placed in the abdominal wall. Six of these had well-marked weaknesses. This is in marked contrast with other series reported.

CHART IV

Respiratory Diseases as Possible Etiological Factors in the Production of Post-operative Abdominal Defects

	Broncho- or Lobar Pneumonia	Defects
Clean cases:		
McBurney (196)	8	0
R. rectus (128)	6	0
Kammerer (18)	1	0
R. Kammerer (15)	1	0
Drained or infected cases:		
McBurney (166)	7	5
R. rectus (90)	6	3
Kammerer (2)	1	0
R. Kammerer (3)	1	0
	Bronchitis	Defects
Clean cases:		
McBurney	2	0
R. rectus	3	1
Drained or infected cases:		
McBurney	2	0
	Tuberculosis	Defects
Drained cases:		
McBurney	2	0
	Cardio-asthmatic	Defects
Drained case:		
R. rectus	1	1

The second group are five cases that developed true fecal fistulæ, none draining less than three months. Of these, only one developed a weak wall (true hernia) and it happened to be in a case where the abdominal was not sutured. The third group is one of eight cases that following the operation became pregnant and had a child. None of the eight developed any weakness in spite of the fact that four of them had been drained at the original operation.

CHART V

Incidence of defects following:

(1) No closure or incomplete closure of the abdominal wall			
McBurney incision	9 cases developed	5 herniæ	55%
Transverse incision	1 case developed	1 hernia	100%
(2) Fecal fistula			
McBurney incision	4 cases developed	1 hernia	25%
R. rectus incision	1 case developed	0 hernia	
(3) Incidence of herniæ in cases subsequently becoming pregnant			
McBurney incision	2 clean	No hernia	
	1 drained	No hernia	
R. rectus incision	1 clean	No hernia	
	1 drained	No hernia	
R. Kammerer incision	1 clean	No hernia	
	1 drained	No hernia	
Transverse incision	1 clean	No hernia	

It may be mentioned here that in all the 700 appendicectomies studied, not one was found to have had a disruption of the wound.

Fully realizing that it is often difficult if not impossible to differentiate between a true incisional hernia and some lesser post-operative abdominal-wall defect, nevertheless an attempt is made in Chart VI to subdivide the ones noted at the follow-up examinations. As can be immediately appreciated, the percentage of incisional herniæ can be raised or lowered very materially depending on how many bulges are classified as herniæ or *vice versa*. Frankly, it is our opinion that the majority of bulges are herniæ. As this term is still used, however, a separate heading was made for them.

CHART VI

Subdivision of All the Post-operative Abdominal-wall Defects

	Hernia	Diastasis	Bulge	Weakness	Muscle Paralysis	Totals
McBurney	16	1	18	3		38
R. rectus	12	10	12	2	2	38
Kammerer			1			1
Transverse	4		1			5
McBurney with Weir ext.			1			1
	32	11	33	5	2	83

Analysis

32 herniæ in 700 cases 4.5%
51 other defects 7.2%
16 McBurney herniæ in 386 cases 4.2%
12 R. rectus herniæ in 250 cases 4.8%

In the seventh chart (Chart VII), finally, the progressive changes and retrogressions noted at the follow-up examinations are listed. It is evident the greater number of defects are found shortly after the operation and at subsequent examinations show no change. A smaller group, however, does. Some from bulges become true herniæ while others apparently recover from whatever defect they might have had. Several other features were studied. An attempt was made to determine whether any particular organism produced more defects than some other. However, not enough cultures were recorded to draw any definite conclusion on this question. As to the age of the patient being an etiological factor, it was found that some patients as young as fifteen developed weaknesses while the oldest was sixty-seven. Returning to a comparison of the McBurney and R. rectus cases, it was found that of the thirty-eight defects noted through an intramuscular incision the average patient's age was twenty-eight years while the ones that occurred through the split rectus were nearly forty years of age. It must be remembered, however, that the average age of all the McBurney cases was twenty-five while the age of the rectus group was thirty-five. The inference to be drawn in our opinion is that probably the diagnosis of acute appendicitis was more clear-cut in the younger individuals and consequently the intermuscular incision was used more frequently in them.

CHART VII

Course of Defects Noted at Subsequent Follow-up Examinations

Incisions
McBurney:
31 no change
1 bulge became a hernia
3 bulges became solid
1 hernia disappeared
2 herniæ developed, 1 eight months and 1 fourteen months post-operatively
R. rectus:
28 no change
6 bulges became herniæ
2 bulges became solid
2 herniæ developed, 1 twelve months and 1 eighteen months post-operatively
Transverse:
3 no change
1 hernia disappeared after nine months
1 hernia developed twenty-three months post-operatively
Kammerer:
1 bulge, no change
McBurney with Weir ext.:
1 bulge, no change for fourteen months, solid at twenty-four months
Résumé: 83 defects out of 700 cases showed that in their follow-up examinations:
63 did not change
6 bulges became solid
7 bulges became definitely herniæ
2 herniæ disappeared
5 herniæ developed anywhere from eight months to twenty-three months post-operatively

SUMMARY.—In a series of 700 cases of appendicitis operated upon through an incision in the right lower quadrant of the abdomen it was found that eighty-three, or about 12 per cent., had some post-operative abdominal-wall defect. These ranged from a simple weakness to herniæ involving the whole length of the incision. The value of accurate and repeated follow-up examinations is definitely brought out by a study of this type. It is well demonstrated that cases operated upon through a split rectus incision are followed by approximately twice as many defects as the intramuscular ones. It is also proven that the defects are about double in men as compared to women. Respiratory complications following the operation apparently have no bearing on the development of these weaknesses.

In cases of appendiceal abscess where the abdominal wall was not sutured or only loosely approximated, many incisional herniæ followed. On the other hand, fecal fistulæ *per se* did not seem to produce any defect. Pregnancy and parturition even in cases that had been drained apparently did not cause the incision to give way.

That weaknesses and even herniæ disappear as time goes on was well brought out. The records also proved that herniæ could suddenly develop a year or more after the original operation. How many in our series were truly incisional herniæ is difficult to say. According to the subdivision in Chart VI, only thirty-two were classified as such. It is our impression,

however, that a fair number classified as bulges are herniæ with a large opening. In conjunction with this thought there is the possibility also that some of the bulges may be incomplete disruptions of the wound, that is, the external oblique fascia or anterior sheath has held but the peritoneum and the overlying muscle have given way. To clear up this point it seems to us that more care should be given in the description of the pathology as found at operation when these defects are repaired.

CONCLUSION.—This analysis we believe gives an accurate picture of the post-operative healing of the abdominal wall following appendicectomy.

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TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

STATED MEETING HELD FEBRUARY 28, 1934

The President, Dr. Allen O. Whipple, in the Chair

UNILATERAL EXOPHTHALMOS

Case I.—Dr. J. William Hinton presented a woman, fifty years of age, seen first June 4, 1931, stating that she had been well until December, 1930, at which time she became nervous and was losing weight. She was not alarmed about her condition until May 1, 1931, when she consulted Dr. L. F. Bishop, Jr., and entered the Midtown Hospital for one week. At that time she was thirty pounds underweight, and her basal metabolism was plus 42. With sedatives she felt greatly improved and her basal metabolism dropped to plus 30 while in the hospital. After observing her for one month, Doctor Bishop felt that she should be operated upon and advised the patient to that effect. At the time of my examination, June 4, 1931, there was a definite enlargement of the thyroid with a thrill over neck, pulse 116, and a definite tremor of hands. There was no exophthalmos and the patient was not extremely ill. She preferred waiting another month before entering the hospital for operation. The patient returned June 17, stating that her right eye had been enlarged for four days, and at this time there was a definite exophthalmos of the right eye. She entered Post-Graduate Hospital the same day, and was immediately put on 20 mm. of Lugol's solution, q. 4 h., with 1 gr. of luminal, t. i. d.; her basal metabolism June 24 was plus 24. Operation, June 25, consisted of a subtotal thyroidectomy, removing about nine-tenths of the right and left lobes, and the entire isthmus. An uneventful convalescence followed operation and she left the hospital seven days later. Her exophthalmos has shown gradual improvement since the operation but it took two years before it disappeared. Basal metabolism done February 25, 1933, was minus 18, and she has had no complaints referable to her goitre, although she still has a slight exophthalmos in the right eye. She was last seen February 22, 1934, plus 80, and no symptoms of hyperthyroidism. There was a slight stare of the right eye but no exophthalmos.

Remarks.—This case is extremely interesting as the unilateral exophthalmos was first noticed by the patient four days before entering the hospital, and from the date of onset of the exophthalmos to the time of operation was eleven days. In spite of the early operation the exophthalmos receded very slowly and it was evident two years later. Symptomatically, the patient has been entirely well and her basal metabolism one year and eight months after the operation was minus 18.

Case II.—Female, thirty-two years of age, first seen February 22, 1932, complaining of enlargement of right eye and having suffered from a goitre for the past three and one-half years. The patient first noticed symptoms of exophthalmic goitre three and one-half years before consulting me and while

under the care of different physicians had had in September and October of 1928 nine weeks of hospitalization, with bed rest, with definite improvement in her symptoms. At the time of entering Miss LeRoy's Sanitarium in September, 1928, her basal metabolism was plus 47 and recheck two days later was plus 49, these tests being done by Doctor Bailey at Post-Graduate Hospital. After nine weeks of rest her metabolism was minus 2. She received Lugol's solution mm. 10, t. i. d., and luminal gr. 1, t. i. d. Following this she felt well, but one year later, in July, 1929, she noticed her right eye enlarged. Numerous basal metabolisms were done during the next two and one-half years which varied from plus 16 to plus 32, and at the time of her visit to me, February 22, 1932, she felt relatively well, except for the enlargement of her right eye. Just before this she had returned from Cleveland Clinic, where they had advised immediate operation. Her basal metabolisms done there were plus 22, and two days later plus 48. The metabolism done by me was normal, pulse 100, blood-pressure 130/70. There was only a slight thrill over neck and no thyroid enlargement. The unilateral exophthalmos of right eye was the only positive finding. She was seen at frequent intervals from February until September, 1932, and remained free from symptoms with the exception of the prominence of her right eye. September 7, 1932, her metabolism was plus 14, pulse 108, blood-pressure 130/70. She then had a definite tremor of hands, thrill over neck and more definite symptoms of an hyperthyroidism than on previous visits. An operation was advised but she hesitated and, on September 21, her blood-pressure was 150/100, tremor of hands more definite and right eye more prominent. She entered the Doctors Hospital on October 19 for operation and after Lugol's solution mm. 20 q. 4 h., and luminal gr. 1, t. i. d., she was operated upon October 31, 1932. After exposing the thyroid gland, five-sixths of the right and left lobes were removed, with the entire isthmus. The gross appearance of the gland was that of an exophthalmic goitre. The patient made an uneventful convalescence and left the hospital six days later, with the exophthalmos greatly improved. On November 14 her exophthalmos was practically gone and by December 15 had disappeared; there was no tremor of hands, or palpitation, and she was free from complaints. Blood-pressure at that time was 135/80. On July 17, 1933, patient complained of being very tired, nervous, and was under considerable nervous strain. Examination revealed a slight exophthalmos of left eye but the right eye was normal and her basal metabolism determination July 20, 1933, was plus 6. At this time she noticed a slight fullness on right side of neck and since that time she has had a definite exophthalmos in left eye which has become progressively worse. On October 26, 1933, she had an attack of abdominal pain which was characteristic of cholecystitis, for which she was operated on. Basal metabolism test on February 23, 1934, was plus 8.

Remarks.—This patient is of interest because she had very mild symptoms of hyperthyroidism and a relatively low metabolic reading, in spite of which she was operated upon for an unilateral exophthalmos which entirely disappeared in six weeks, and eight months later developed an exophthalmos of the opposite eye which has been persistent for the past eight months.

Dr. Wm. Barclay Parsons said that the underlying cause of exophthalmos has been and still is a puzzle. Nahfziger with his sections, which have been confirmed by other observers, has come as near as anyone to explaining the mechanism. His operation of decompression of the orbit has produced

good results, but it is a formidable procedure and probably should be reserved for the extreme cases where there is a real danger of destruction of the eyeball. The paradox of exophthalmos in hyperthyroidism is its irregularity in appearance, its irregularity in subsidence, and the fact that some of the worst cases appear after operation when the metabolism has been brought to normal. It does not seem unusual that in Doctor Hinton's first case automatic improvement did not occur for two years. In the second case the unilateral exophthalmos does not seem bad enough to warrant any procedure at the moment. Section of the cervical sympathetic will produce ptosis, but this procedure has obvious disadvantages. A better method is recession of the levator where the widened fissure is too unsightly.

Dr. Henry H. M. Lyle thought that some of the older members might recall the excitement that was occasioned by Jonnesco's visit to this country some years ago. High hopes were held out that his operation for the removal of the cervical sympathetic ganglia would cure exophthalmic goitre and especially the exophthalmos. While Doctor Lyle was House Surgeon at St. Luke's, some six or seven of these cases were operated upon with but slight improvement in one case.

Dr. Arthur S. McQuillan felt that in his experience resection of the cervical sympathetics for persistent and increasing exophthalmos resulted in only temporary improvement; these had been long-standing cases, however. It is only occasionally that one sees exophthalmos increasing to more severity and to such a degree that ulceration of the cornea and loss of the eye is threatened. The majority of cases of persistent exophthalmos following goitre operations gradually clear although it may take three to five years to do so. In his experience the worst cases of exophthalmos occurred in individuals who had had subtotal thyroidectomies.

Although interesting, the mechanism of exophthalmos is an unsolved problem at the present time. It is known that exophthalmos occurs in other conditions than Graves' disease, such as severe decompensated cardiacs, in severe nephritics and often following asphyxiation. Conditions in which there is an apparent reduction of oxidation to a considerable degree and a corresponding increase in carbon dioxide. It was on this theory that Dr. David Marine recently showed the result of some experiments on rabbits, in which he was able to produce marked bilateral exophthalmos by reducing oxidation in this animal to an extreme degree. First by extirpating the thyroid gland which would lower the oxidation processes and then feeding the animal methylene cyanide which further lowers the oxidation processes. This is suggestive of a possible centre in the involuntary nervous system or brain which more or less controls the sympathetics, acting on the orbital smooth muscle which has control of the orbital septum.

Doctor Hinton, in closing, said that his reason for presenting the first case was to contrast it with the second. It was hard to explain the improve-

ment in the latter. Her metabolism had stayed down and she had no symptoms of hyperthyroidism. It was hard to conceive how the swelling of the eye muscles could have improved so rapidly in this woman. The question of cervical sympathectomy had been suggested to her and she had been advised that the result might be unsatisfactory.

FEMORAL EMBOLECTOMY

DR. FRANK L. MELENEY presented a man, aged 44 years, who was seen first in the Surgical Diagnostic Clinic of the Presbyterian Hospital in June, 1928. He then complained of indigestion. He gave a history of rheumatic fever in childhood. Nothing surgical was found. Examination revealed an enlarged heart with systolic and presystolic murmurs at the apex and systolic and diastolic murmurs over the aortic area. At that time the heart seemed to be compensated. He was transferred to the cardiac clinic, where he was seen off and on for three months and then he did not return for four and a half years.

In February, 1933, he came into the clinic with signs and symptoms of mild cardiac decompensation. It was found that he had mitral stenosis and insufficiency, aortic insufficiency and auricular fibrillation. The X-ray showed left auricular and ventricular enlargement and a bulging of the great vessel shadow to the right indicating a diffuse dilatation of the ascending aorta. The electrocardiograph showed auricular fibrillation with ventricular premature beats. Intraventricular conduction time was at the upper limit of normal. The findings suggested myocardial fibrosis. All tests for lues were negative. The blood and spinal fluid Wassermann reactions were negative. He was kept on digitalis and was followed in the medical clinic as an ambulatory patient. He was seen last in the clinic on September 6, 1933, when a note stated that he felt very well and had no dyspnœa except on great exertion.

On September 17, 1933, at 6 P.M., he made a sudden movement in an effort to avoid a blow. Directly afterward he felt "pins and needles" in the right leg below the knee and the whole leg quickly became numb. Numbness rapidly increased in spite of his attempts to restore sensation by slapping and rubbing the leg and soon it felt very heavy. Pain was not severe at first but steadily increased. He did not notice any change in color but the leg became colder and he hastened to the hospital where he arrived within an hour of the time of onset. He was in acute pain. His heart was enlarged and gave aortic and mitral systolic and diastolic murmurs with a mitral presystolic. It was fibrillating slowly with no pulse deficit. The right lower extremity was cold and pale with irregular blotches of cyanosis. This pallor and coldness extended up to the middle of the thigh, somewhat higher on the inner side than on the outer side. Above that there was a fairly abrupt change, for the skin felt warm and had a normal color. No pulsation could be felt over the dorsalis pedis, posterior tibial or popliteal arteries. (Fig. 1.) The femoral could be felt below Poupart's ligament but the pulse rapidly diminished in strength from above downward and could not be felt in the mid-thigh.

The patient was prepared for operation at once and under spinal anæsthesia an oblique incision was made below Poupart's ligament along the course of the femoral artery. At first it was difficult to distinguish transmitted pulsation from expansile pulsation but by careful palpation it was finally determined that expansile pulsation was present only above the division of the common femoral and at this site a resistance could be felt within the vessel which indicated the presence of the clot. (Fig. 2.) Soft rubber tubes were

passed beneath the common femoral and beneath each of the major branches. While gentle traction was made on these tubes an incision 2 centimetres long was made over the clot and when the pressure above was released the clot popped out. Then, even though pressure was applied again, arterial blood flowed freely from a vessel entering on the posterior wall of the common femoral—evidently a high internal circumflex artery. A rubber protected curved clamp was then applied longitudinally to the whole artery in the region of the incision. This controlled the bleeding and everted the edges of the

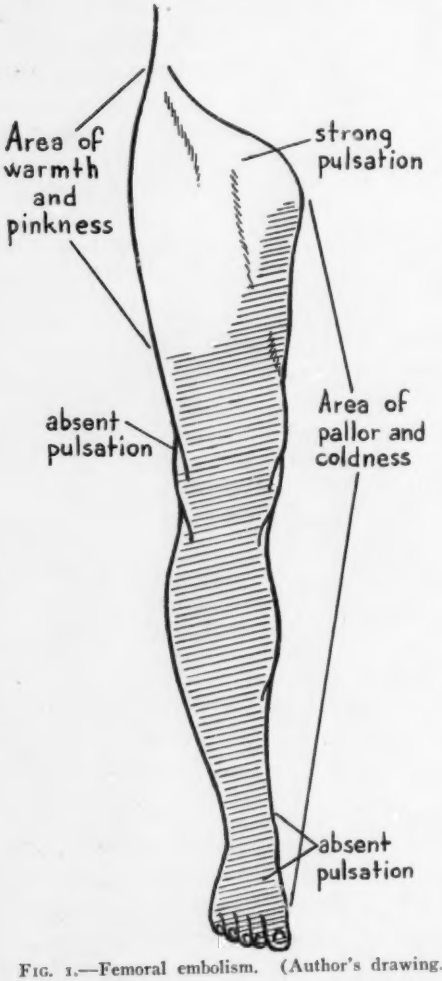

FIG. 1.—Femoral embolism. (Author's drawing.)

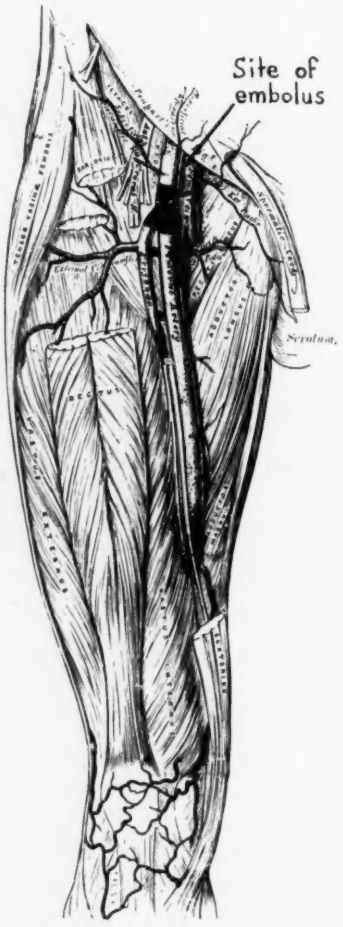

FIG. 2.—The femoral artery. (Adapted from Gray's Anatomy.)

incision. These were smeared with vaseline and the incision was sutured with fine arterial silk by means of an over and over stitch. When the clamp was removed, there was the very slightest amount of ooze from the suture line which promptly stopped. An assistant was then asked to feel for the pulse at the ankle and he reported strong pulsation both in the dorsalis pedis and in the posterior tibial. The fascia was closed over the artery with fine silk and the skin sutured. On examining the leg after operation the pulses felt normal and the color and warmth had returned so that no difference could be seen or felt between the two legs.

Normal sensation returned promptly and there was no diminution of pulse or color throughout his hospital stay. The wound healed kindly and he left the hospital on the thirteenth post-operative day. He has been seen in the clinic six times since then and has had no symptoms referable to his leg. He returned to work within a month of his discharge from the hospital and has been working ever since.

The embolus measured 2.2 by 0.9 centimetres and had projections corresponding to the superficial and deep branches of the femoral and the internal circumflex artery. (Fig. 3.) The centre of the clot was old and contained hæmosiderin and degenerating leucocytes but showed no organization. The outer part of the clot was recent and corresponded in form to the vessels in which it was contained.

The case is presented to illustrate the favorable result which is occasionally obtained following an early operative procedure, which was carried out just four hours after the accident occurred.

Dr. Harold Neuhof said that the case was one of the exceedingly rare instances of real results that have been obtained in embolectomy for embolism

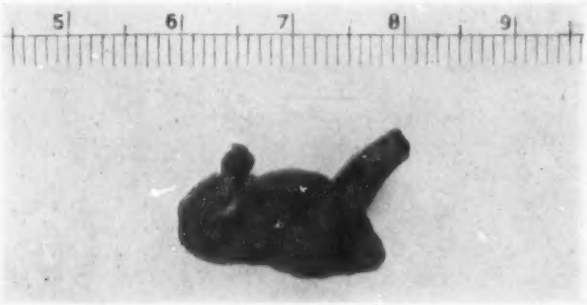

Fig. 3.—Embolus from femoral artery. (Scale shows centimeters.)

of the peripheral arteries. That does not mean that results have not been obtained by others, but it does mean that with most favorable results following embolectomy, through circulation did not occur after operation. In looking through the literature, very few cases are reported which show the criteria of results described by Doctor Meleney. The reported cases in which satisfactory functional results were obtained were of the type described by Doctor Stetten in a case which he recently presented before this society. In his case there was an entirely satisfactory functional result without reëstablishment of the through circulation. Doctor Neuhof stressed these reported results because they are in striking contrast to Doctor Meleney's demonstration of through circulation following embolectomy. In his case the ideal result is undoubtedly to be based on the fact that he had the rare opportunity of operating so soon after the lodgment of the embolus. In most cases the embolus has been lodged for many hours longer before the patient comes to operation. It is in these cases that there cannot be a reasonable expectation of the establishment of through circulation. The changes in the vessel wall at the site of embolization are almost sure to invite the development of post-operative thrombosis if the embolus has been lodged for longer periods. Under such cir-

cumstances there is good reason to anticipate more or less complete occlusion of the vessel after operation. That this in itself may not lead to a poor functional result is proven by the successful cases reported in the literature. There is, however, grave danger of the detachment of the new thrombi by whatever through circulation occurs shortly after operation, and their lodgment at lower levels. Survival of the extremity is of course jeopardized by blockage at lower levels when there is more or less obturation at the site of embolectomy as well. Doctor Neuhof has accordingly advocated another form of closure after embolectomy when the embolus has been lodged for long periods. It consists in a closure by mattress sutures of the incision in the artery, whereby broad approximation of intima is attained and the diameter of the lumen is deliberately narrowed.

Dr. DeWitt Stetten congratulated Doctor Meleney on his beautiful presentation of a very definite result of peripheral embolectomy, and stated that at the last October meeting of the society he presented a similar, but by no means as striking, case in a woman of fifty-eight years, also suffering from mitral disease, who shot an embolus into her right common femoral, which extended upward into the external iliac. The patient was seen a short time after the accident, but the embolectomy was done seven hours after, the delay being due to the necessity of obtaining the family's consent. Although, as Doctor Neuhof had mentioned, the evidence of completely normal circulatory restitution was not as convincing in this case—*i.e.*, the presence and persistence of actual expansile pulsation at the site of the embolectomy after the extraction of the embolus and the arterial suture, and the return of the dorsalis pedis pulse—the limb that had been cadaveric before promptly regained its vitality and became and remained quite normal in color, temperature, sensation and function. As Doctor Stetten suggested in his report, the probability in his case was that the removal of the clot, if it did not permit normal anatomical restoration of the circulation, at least permitted free collateral circulation with which the clot interfered. This opinion was supported by the appearance of propulsive pulsation in the common femoral above the arterial suture after the embolectomy, which was absent before. At any rate Doctor Meleney's presentation was a most convincing corroboration of the contention made by Doctor Stetten at the time of his presentation; namely, that peripheral embolectomy is not only justified but definitely indicated in suitable cases.

Dr. John A. McCreery remarked that these cases were infrequent enough to warrant reporting. Some of the unsatisfactory results of embolectomy were due to the fact that one is operating on a complication or a symptom rather than on the cause of the disease and further emboli may occur. The speaker had one case on his service at Bellevue Hospital operated on by Dr. W. F. Cunningham in which a femoral embolus was removed with satisfactory results with immediate return of circulation. The man was a chronic cardiac and while still in bed had an iliac embolus. This was removed

satisfactorily. Some weeks later he had a cerebral embolus from which he died.

Dr. Wm. Barclay Parsons said hat three or four years ago he had a case with advanced hyperthyroidism associated with auricular fibrillation. The patient had mild pains, probably embolic, in the right lower leg. A day later a severe painful episode developed, presenting the classical picture of embolus with involvement of the entire left leg. Doctor Parsons saw her the next morning, opened the femoral artery, then went into the abdomen and removed a branched embolus which filled the left common iliac and extended down the external iliac to Poupart's ligament and down the internal iliac for a distance of 4 centimetres. The lower leg did not recover; there was gangrene of the foot and lower part of the leg. Amputation of the leg through the knee was done and an embolus was found below the popliteal. The patient died a month later, and at autopsy her heart showed no suggestion of any auricular thrombosis. The common and external iliac arteries were clear, but the internal iliac was completely obstructed. In all probability the first attacks were due to a small embolus, and the more severe one was due to the clot in the common iliac.

Dr. Frederic W. Bancroft felt it was only fair to report failures, as well as successes, and that in 1928 he had performed three embolectomies. In two of these cases amputation had to be performed the following day because the circulation had not been reëstablished. The third patient died of shock. Two of these patients, who had emboli in the popliteal arteries, were myocardiacs with quite marked arterial disease, and in both of these amputation was performed. The third case, an embolus in the brachial artery, died from shock. The two cases of emboli in the popliteal arteries were twelve to twenty-four hours old when admitted to the hospital.

Doctor Meleney, in closing, said that he believed the successful outcome in this case was largely due to the patient himself who had the good judgment to go to the hospital so promptly. The accident happened at 6 P.M. and he reached the hospital at 7:15 P.M. There was more delay than there should have been in handling an emergency of this kind because he was a cardiac case and the admitting interne called the medical resident. Doctor Meleney did not see the patient until 9:15 P.M. Operation was started at 10:10. The clot had not enlarged itself beyond the site of the lesion; otherwise, it is doubtful if the result would have been so successful. Of the eight cases at the Presbyterian Hospital which had been diagnosed femoral embolism in the last twenty years, this was the only one which had been successfully operated upon. No cases of femoral embolectomy were listed in the diagnosis file prior to 1914. The case presented this evening was one of three in which embolectomy had been done. Another was the case referred to by Doctor Parsons. The third is now in the hospital. Gangrene developed following embolectomy and amputation was performed. In a case of Doctor Bull's, the patient came to the hospital two days after the accident, gangrene

set in and amputation was done. There were several cases in which there were multiple emboli, cerebral as well as femoral. The others were in such desperate condition when they entered the hospital that no operation could be done.

CAVERNOUS HÆMANGIOMA OF THE FOREARM

TREATED WITH REPEATED INJECTIONS OF 30 PER CENT. SODIUM SALICYLATE

Dr. Frank L. Meleney presented an unmarried woman of thirty-five years admitted to the skin department of Vanderbilt Clinic April, 1929, complaining of an irregular lobulated soft swelling of the left forearm which had been gradually growing for ten years. Several doctors had previously advised her to let it alone but it was giving her great concern because the swelling seemed to be slowly spreading upward above the elbow and downward into the hand. Furthermore she was having increasing difficulty in using her arm because of its rapid increase in weight and stiffness after a short period of dependency. She found that she could prevent swelling of the hand by wearing a tight band around the wrist. Dr. George Andrews, who was in charge of the case, decided to try high-voltage X-ray treatments. These she received at weekly intervals for a period of five weeks without improvement and he then referred her to Doctor Meleney for an opinion with regard to surgical therapy. At that time all of the forearm and the region around and above the elbow were involved in a soft, compressible, lobulated, bluish swelling which was not tender and gave no pulsation. Pressure and elevation easily reduced the swelling but it recurred as soon as the pressure was released, or the arm assumed a dependent position. It was also evident that the process extended slightly down into the hand both on the dorsal and palmar surfaces as far as the proximal phalanx of the ring finger. It seemed certain that we were dealing with an extensive and progressive cavernous hæmangioma. It was also apparent that any surgical procedure, to be effective, would have to be very radical. It was, therefore, decided to attempt to obliterate the cavities with some sclerosing fluid. Injections of 30 per cent. sodium salicylate, varying in quantity from 1–5 cubic centimetres, were made in different parts of the tumor at bi-weekly intervals over a period of eight months. At first the injections were fairly large in amount because of the size of the sinuses, but later as the tumor became smaller the quantities were reduced. In the early treatments as much as 5 cubic centimetres were injected in each of five different places. This was followed by transient ringing of the ears, dizziness, and some headache. On the day following injection the areas usually became swollen and painful but after a few days the swelling subsided leaving the areas contracted. Two of the injections caused small areas of skin necrosis, but in spite of these, the patient and the doctor were greatly encouraged, for the tumor in the arm and the forearm gradually became completely sclerosed. The patient found that she could lower the arm for long periods without any difficulty and she was soon able to use it at housework and sewing with increasing ease. The only disturbing feature lay in the fact that it seemed to be spreading into the hand and one hesitated to inject any sclerosing fluid there for fear of its effect on the small anatomical spaces. This was attempted, however, on several occasions with very small quantities when one could be sure that the needle was in the cavity of the tumor and in several places it resulted in a disappearance of the tumor. Once it caused a stiffness of the index finger evidently from some scar tissue forming around the extensor tendon. Gradually, around the wrist, swellings appeared which were very superficial and colorless, like lymphangioma rather than hæmangi-

oma. These have been watched with considerable interest but have not increased to any degree over a period of more than two years. For the last two years the patient has been seen at monthly intervals and the tumor has shown no evidence of any spread until the last visit when there appeared to be a recurrence of the process around the elbow. This will probably need further treatment. The function of arm and hand have been entirely satisfactory. Doctor Meleney has been particularly gratified that there has been no further spread into the hand. Although there is still some evidence of its presence there, it does not incapacitate her and if at any time a cavity should form which is large enough to permit aspiration, it would be safe to inject a small quantity of sclerosing fluid with the expectation of obliterating the cavity. The case is presented in order to illustrate the possibility of arresting the spread of a large cavernous hæmangioma by means of repeated injections of a sclerosing fluid.

Dr. Grant P. Pennoyer said that this case illustrated the fact that there may be latent therapeutic possibilities in the destruction of endothelial and serous surfaces by chemical means. Doctor Meleney certainly did very well with this case by injections of sodium salicylate. The speaker had tried this treatment in two cases of angiomata with only inferior results. He believed now that he was discouraged too quickly and the results in the case presented this evening had encouraged him to try again. The treatment was theoretically sound and should be studied further. There was very little in the literature on this aspect of the subject. Surgeons should keep an open mind on the injection treatment. Doctor Pennoyer recently saw two cases of congenital hernia in children which had apparently perfect cures by obliterating the sac with quinine solution. It had been injected through a very small incision just below the external ring and the child allowed out of bed the next day wearing a truss. The speaker had not treated these cases and he realized that most surgeons would regard this as most dangerous heresy. Probably it was dangerous, but it might be possible to work out a technic making it safe to cure congenital herniæ in the out-patient department of hospitals. The cases mentioned were done by a medical man in a private hospital. The chemical treatment of hydrocele needed further study. It was not beyond the range of imagination that an arthrodesis could be done chemically. Doctor Pennoyer did not recommend these procedures, but advised an open mind on the subject.

Dr. Frederic W. Bancroft referred to a case of congenital hæmangioma of the rectosigmoid which he had reported three years ago, where the treatment had been similar to Doctor Meleney's case. The patient, a boy aged sixteen years, had had hæmorrhages from the rectum since the age of two. On admission his red blood-count was down to 3,500,000, and he was quite markedly anæmic. He was weak and had not been able to carry on his ordinary school duties. Blood was always present in the stools and frequently he had severe hæmorrhages. On proctoscopic examination one could see large venous lakes immediately beneath the mucosa. This condition extended upward over twelve inches. The patient was sent to Dr. Harvey Stone in

Baltimore, who confirmed the diagnosis of hæmangioma of the rectosigmoid. It was decided that the hæmangioma was largely venous in character and therefore injection of the lower branches of the inferior mesenteric artery might cure the condition. As no case had been on record of a similar procedure it was thought advisable to do a sigmoidostomy in order to shut off the fecal stream. At operation the hæmangioma was clearly observable beneath the peritoneum. Large dilated venous channels were seen spreading over the sigmoid. The distribution corresponded to practically that of the superior hæmorrhoidal veins. The superior hæmorrhoidal vein was cut between ligatures and the distal end injected with 20 cubic centimetres of a 20 per cent. sodium salicylate solution. A sigmoidostomy was then performed. His convalescence was uneventful. His sigmoidostomy was closed after a year. It is now three years after the closure. He has had no gross bleeding, is well, and is attending city college; he has only occasionally a small trace of blood when straining at stool. Proctoscopic examination shows some dilation of the hæmorrhoidal vessels, but above this area the mucosa is smooth and has lost its bluish appearance.

Dr. Franz Torek said that the use of chemicals was not the only means of curing cavernous hæmangioma. In a number of cases he had used boiling hot water with good results. About a year ago he had under his care a patient with an enormous cavernous hæmangioma situated deep in the muscles of the shoulder extending from the occiput down as far as the lower end of the scapula and outward to the acromion, which he tried to extirpate. After it was about half removed the hæmorrhage became so profuse that it could not be controlled; the operation was halted, large sutures were placed to encompass the bleeding masses and the boy was left to recover. About three weeks later, instead of trying to continue the operation, injections of boiling water were made under narcosis throughout the entire mass. This was repeated four or five times at intervals of two or three weeks to destroy the remaining parts of the cavernous tissue. The boy eventually was completely cured. It could be assumed that he would have been cured without the preliminary operation.

Dr. William B. Coley reported a case of cavernous angioma in a girl, four and a half years of age, who was first observed at the Hospital for Ruptured and Crippled on July 7, 1925. She had a rapidly growing tumor of the calf of the leg of two months' duration. The clinical diagnosis was that of angiosarcoma. Doctor Coley performed a mid-thigh amputation on July 16, 1925. *Pathological report* by Doctor Jeffries: Extensive and intense acute myositis with multiple abscesses and widespread œdema and extensive proliferation of blood-vessels and lymphatics, both of which have in places become fused and cavernous. He does not rate this vascular condition as angioma but rather the result of pressure. He fails to find any neoplasm. This diagnosis was confirmed by Doctor Ewing. Two years later there was a marked recurrence in the stump extending up to the hip. The tumor gradu-

ally increased in size and on May 23, 1928, the patient was admitted to the Memorial Hospital for irradiation. (X-rays and radium.) The tumor involved the entire gluteal region and extended beyond the crest of the ileum in front. The case was regarded as quite hopeless in 1932. Further X-ray treatment was given in 1932 and 1933. The latest note on the case made on February 3, 1934, stated that the child looked well, had no pain and was attending school regularly.

ONE-STAGE ORCHIOPEXY FOR UNDESCENDED TESTICLE

Dr. Edward W. Peterson, before presenting six cases, said that "while the testicle may be arrested anywhere in the course of its descent to the scrotum, in the majority of cases the organ will be found in the inguinal canal at the external abdominal ring, or just outside of the ring. In the operation for the correction of this deformity, three main difficulties are encountered, *viz.*, the inelastic vaginal process of peritoneum, the deficiency in length of the vessels of the cord and the small size of the scrotum, especially where the cryptorchidism is bilateral. The one big problem, as we see it, in any and every case, after the peritoneal process has been separated from the cord and properly dealt with, is to obtain sufficient lengthening of the vascular elements of the cord, so that the testicle will hang free from the body and at the bottom of the scrotum (the vas deferens is never too short and does not give rise to any trouble in the operation). No matter how small the scrotum may be, it is so elastic and capable of such distention, by one means or another, that it will accommodate itself to a testicle of any size.

Operation.—The technic of operation is essentially that of Bevan. The vessels are freed, in some cases, as high as the lower pole of the kidney, as advocated by Moschowitz, in order to over-correct the vascular shortening of the cord.

Case I.—Larry Makler, aged thirteen months; operated upon January 16, 1934. Diagnosis: Right undescended testicle and right indirect inguinal hernia. The testicle was in the canal. Operation: One-stage orchiopexy; appendectomy; hernioplasty without transplantation of cord. Immediate result good.

Comment.—Several attacks of severe abdominal pain, suggesting torsion of the cord, were responsible for the early operation in this case. At operation the distal end of the appendix was found in the hernial sac, and the organ both macroscopically and microscopically showed definite evidence of disease.

Case II.—Philip Mascola, aged seven years. Diagnosis: Bilateral cryptorchidism and bilateral indirect inguinal hernia. Both testicles were in the canal at external ring. Operation: November 29, 1932. One-stage left orchiopexy and left hernioplasty without transplantation of cord, with the result that the testicle came well down in scrotum, no atrophy. Second operation: January, 1934. One-stage right orchiopexy and right hernioplasty without transplantation of cord with good immediate result.

CASE III.—Edward Woods, aged seven years. Diagnosis: Bilateral cryptorchidism and right indirect inguinal hernia. The testicles were both abdominal, the right could be felt at the internal ring. Operation: October 7, 1932. One-stage right orchiopexy; appendectomy and herniotomy without transplantation of cord, resulted in the testicle coming well down in scrotum, no atrophy. Left testicle still within the abdomen. Will be operated upon in the coming June.

Comment.—This patient was under observation for ten months before operation was performed. He has been taking anterior pituitary, thyroid and suprarenal treatment up to the present time, without any appreciable effect on the descent of the testicles.

CASE IV.—John Lucchese, aged seven years. Diagnosis: Left undescended testicle and left indirect inguinal hernia. The testicle was in canal at external ring. Operation: March 29, 1928. One-stage orchiopexy; hernioplasty without transplantation of cord, resulted in placing the testicle in bottom of scrotum, no atrophy.

CASE V.—Joseph Cerveny, aged thirteen and one-half years. Diagnosis: Left undescended testicle; left indirect inguinal hernia; Von Recklinghausen's disease. Operation for infantile pyloric stenosis, April 26, 1919. The testicle was at the external ring, very small, merely a rudimentary bud. Operation: July 25, 1932. One-stage orchiopexy; hernioplasty without transplantation of cord, resulted in the testicle having grown considerably, but it is smaller than the normal.

Comment.—At the time of operation the small genital organs and the excess of pubic fat suggested the possibility of pituitary dysfunction. Since operation there has been striking improvement in the general development of the patient, and the position and size of the testicle is most satisfactory.

CASE VI.—Abraham Margolini, aged twenty-five years. Diagnosis: Left undescended testicle, atrophic, bilateral indirect inguinal herniæ; right testicle high and atrophic, but in scrotum. The left testicle was outside the external ring. Operation: December 19, 1920. One-stage orchiopexy and bilateral hernioplasty; Bassini on right; cord not transplanted on left, resulting in the left testicle in bottom of scrotum and now considerably larger than right.

Comment.—In operations performed after puberty, the atrophic testicle usually shows absolutely no tendency toward further growth or development. The unusual result in this case is both surprising and gratifying. An examination of the patient's seminal fluid a few days ago showed the presence of active, motile spermatozoa.

DR. WILLIAM B. COLEY referred to a recent article of his on this subject (ANNALS OF SURGERY, October, 1933) and stated that he had been greatly interested in the subject of undescended testis and its treatment ever since he began his service at the Hospital for Ruptured and Crippled in 1890, at which time they had each year about five thousand cases of hernia in the Outpatient Department. They had just begun to operate for the radical cure of hernia. A few years later he made a study of 80,736 cases of inguinal hernia in the male and found 1,357 or 1/65 per cent. associated with undescended

testis. Up to that time very few adults had been admitted to the hospital; most of the patients were under fourteen years of age. From 1890 to 1918, 4,453 cases of inguinal hernia in the male had been operated upon, of which 334 or 7.5 per cent. were associated with undescended testis. The majority of these cases also occurred in children under the age of fourteen years. As regards the undescended testis in adults, of 1,040 cases of hernia operated upon at the Memorial Hospital by Dr. William A. Downes and Dr. William B. Coley, 49 or 4.71 per cent. were associated with undescended testis.

Doctor Coley's first operation for undescended testis was performed in 1893. At this operation he divided the sac and sutured the lower end over the testis, making a new tunica vaginalis. He then dissected the proximal end of the sac as far up as possible, well beyond the internal ring, and freed the cord from the bands of fascia thereby making it possible to bring the testis into the scrotum in most cases. In the first few cases he transplanted the cord according to the Bassini method but Doctor Bull, in 1893, omitted the transplantation step, thus adding about one-half inch to the length of the cord. This procedure Doctor Coley immediately adopted. Up to 1899, Doctor Bull, Doctor Walker and Doctor Coley had performed twenty-six operations for the undescended testis. Most of these cases were operated upon by the Bassini method with the transplantation step omitted. In all it was possible to place the testicle in the scrotum. In September, 1899, Doctor Bevan published his first paper describing his method of treating undescended testis, and in September, 1903, he published a second article. While the method they had employed at the Hospital for Ruptured and Crippled from 1893 to 1899 was very similar to the one employed by Bevan, neither Doctor Bull nor Doctor Coley had ever published an account of the technic Bevan was the first to do this, and hence the method was very properly termed the Bevan method. In addition, Bevan added certain other steps which Doctor Coley believed to be of great value. These are: (1) the purse-string suture at the external ring to prevent the testis from retracting and again entering the canal; (2) freeing of the cord well beyond the internal ring (this they already did in their operation), and (3) removing the veins of the cord. The latter Doctor Bevan recommended only in special cases and not as a routine measure. An objection to this is that, in a large proportion of cases, atrophy of the testis follows. Doctor Coley has never found it wise or necessary to remove the veins of the cord.

In May, 1919, he reported 365 cases of undescended testis operated upon at the Hospital for Ruptured and Crippled to which were added fifty cases in adults operated upon by Doctor Downes and Doctor Coley at other hospitals, making a total of 415 cases; seventy-seven were of the inguino-superficial variety, and eight of the inguino-perineal; 149 cases were traced from one to twenty years. While the results were reasonably satisfactory, they were not ideal. In a number of cases the testis had retracted to the region of the external ring and remained in an atrophied condition. There was no case of death or of recurrence of the hernia in the entire series.

When Keating of England brought out his operation for undescended testis, the principal step of which consisted in burying the testis for a short period in the thigh at a level with the scrotum, Doctor Coley was not at all impressed with it. A few years later Torek brought out a somewhat similar operation but with improvements. While this seemed somewhat superior to Keating's, he was still unconvinced that it was sufficiently superior to Bevan's method or the one they employed at the Hospital for Ruptured and Crippled to warrant its substitution. But in 1927 Dr. Herbert Willy Meyer at a meeting of this society read a paper on the Torek method and presented a large series of end-results which were more satisfactory than any Doctor Coley had observed, and he was finally convinced of the superiority of the Torek operation. Later on this operation was employed at the Hospital for Ruptured and Crippled, and in 1933, at the American Surgical Association meeting, Dr. Carl G. Burdick and Dr. Bradley L. Coley read a paper in which the Torek operation was contrasted with the former method of operation. They cited the end-results in 125 cases.

Summing up the whole question, it seems to Doctor Coley better to admit that the results obtained by the Torek operation are more nearly ideal than those obtained by the older methods. At the same time he would reserve the Torek operation for the group of more difficult cases in which it is almost impossible to get the testis in the bottom of the scrotum without great tension, and for the larger group of less difficult cases he would continue to use the Bevan operation which had proved so highly satisfactory in the majority of cases.

The question of when to operate is one on which surgeons have never agreed. While some would operate on young children regardless of the age, he believes that in most cases it is wiser to wait until the patient has reached the age of ten or twelve years, unless there is some special reason for operating, such as an hernia that cannot be controlled. His principal objection to an earlier operation is based on the fact that in many cases as the boy approached puberty the testis descends into the scrotum spontaneously. He does not believe it is possible to determine beforehand in just which cases it will descend and in which it will not.

Doctor Peterson in closing said that he had operated upon cases of undescended testicle by both the two-stage method of Torek, and by the one-stage method described tonight. There was a place for both procedures. It was his belief, however, that the majority of cases could be satisfactorily treated by a single operation.

ABDOMINAL-WALL DEFECTS FOLLOWING APPENDICECTOMY

Dr. Gaston A. Carlucci read a paper with the above title for which see p. 1177, Annals of Surgery, vol. 100.

Dr. Frederic W. Bancroft stated that he had been impressed by the tremendous amount of work that Doctor Carlucci had put into this paper.

It was obvious that he had reviewed all these cases personally, which entailed much more work than if it had been done by clerical assistants. He regretted that the age incidence in the hernia cases had not been reported because he believed it was an important factor, since in a study he had made ten years previously of a series of follow-up cases in the service of Doctor Pool, of the New York Hospital, he found that the incidence of post-operative appendiceal hernia was high up to fifteen years of age, then decreased markedly up to thirty-five years of age and then began again to increase with advancing age. Obviously the years from fifteen to thirty-five are the most active muscular period in an individual's life, and if the incidence of hernia was low at this age it would seem that the factors producing the hernia had occurred while the patient was in the hospital and had nothing to do with his later activities. It seemed to Doctor Bancroft that the producing factors were: First, sloughing fascia and, secondly, prolonged drainage. In prolonged drainage one often sees the skin growing downward about the drainage tube. It is very probable that if one could invert the picture one would see peritoneum growing upward about the tube, producing the initial hernial sac. Doctor Bancroft had followed Doctor Pool's work at the New York Hospital and had utilized the same procedure in the Lincoln and the Fifth Avenue Hospitals. He felt that sutures placed in the fascia, causing constriction, had a great deal to do with the later infection of this fascia with its resultant sloughing. It was his custom, if the wound was large, to put in one or two tension sutures: if the wound was small, tension sutures were unnecessary. If the peritoneal cavity was drained, the peritoneum was closed up to the drains and the remainder of the wound left wide open and packed with vaseline gauze. In many cases where it was felt that the wound might become infected through soiling and that the peritoneum would take care of itself, the peritoneum was closed and the wound left wide open and packed with vaseline gauze. It was his impression that the incidence of hernia was reduced and the hospital stay shortened. He has not had time to procure the figures of the cases at the Fifth Avenue Hospital, but requests permission to show a case at a later meeting, at which time he would give the statistics. Doctor Bancroft agreed with Doctor Carlucci that the problem of whether a bulge was an hernia or not was often difficult to determine. He felt that it made a good deal of difference whether the patient was examined standing or lying down; often the patient lying down showed an hernia while with good muscular control standing up it gave the impression of being a bulge.

Dr. Carl G. Burdick agreed with Doctor Bancroft about the sloughing of the fascia. He remarked that Doctor Carlucci's paper showed that between 16 and 20 per cent. of the acute cases were infected. The speaker believed that when one took out an acute appendix, where one felt the peritoneal cavity could take care of the infection, it would be wise to close the peritoneum and drain down to it. This would forestall a certain amount of infection and consequently avoid some subsequent sloughing of the fascia. In drainage

cases Doctor Burdick felt it wise to suture the peritoneum loosely about the drain but not to suture the fascia or skin.

In regard to the so-called bulges he felt that many of them, particularly in children, had a tendency to disappear in time.

Doctor Carlucci, in closing, said that there were no children on his service, so the age series began at twelve. He had started to make an analysis and found that the largest majority developed an incisional hernia at approximately thirty years of age. The question of differentiating a bulge from an hernia had always interested him; it was one of the reasons why he had written this paper. As to the bulge in the drained and not sutured cases, perhaps the reason why they developed an hernia was because he had not sutured the peritoneum tightly enough, so infection developed with sloughing and produced an hernia later.

TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

STATED MEETING HELD MARCH 14, 1934

The President, DR. ALLEN O. WHIPPLE, in the Chair

SYMPOSIUM ON ACUTE AND CHRONIC EMPYEMA

Four papers were presented covering this field of surgery.

(1) THE TREATMENT OF EMPYEMA, by DR. JOHN F. CONNORS, see p. 1092.

(2) OBSERVATION ON CHRONIC EMPYEMA, by DR. WALTON MARTIN, see p. 1096.

(3) PUTRID EMPYEMA (RUPTURED PUTRID ABSCESS OF THE LUNG), by DR. HAROLD NEUHOF AND DR. SAMUEL HIRSHFELD, see p. 1105.

(4) TREATMENT OF TUBERCULOUS EMPYEMA, COMPLICATED BY PYOGENIC INFECTION, by DR. ADRIAN V. S. LAMBERT, which has previously been published, see ANNALS OF SURGERY, vol. 99, No. 6, pp. 944–948, June, 1934.

DISCUSSION.—DR. HOWARD LILIENTHAL said that it was difficult to discuss the subject of each of the four papers presented as each concerned the other. But he felt that every one had been fortunate in hearing such beautifully expressed and such well-thought-out presentations in which such excellent results had been reported. It left one at a loss to know which particular angle to approach—he would merely call attention to a few points which seemed to him to be of particular interest. First, it was very important to know the cause of the empyema in each case. Tuberculosis, for example, can not be treated by the same methods as pyogenic cases. Again, it was most necessary to watch for complications during the surgical course of the disease. The speaker was amazed, in looking up material for a paper which he recently presented, to learn of the number of fatal complications which have occurred; so one should always be watchful. This was true of pericarditis, although not a common complication. When the patient did not get well promptly, secondary pockets, mediastinitis or pericarditis should be suspected. As to exploratory puncture, Doctor Lilienthal had many times spoken of the danger of this, especially when there was putrescence.

DOCTOR NEUHOF had reported four fatal cases of phlegmon of the chest-wall. This occurred especially when repeated puncture had been performed. Doctor Lilienthal remembered in one case in a neighboring city where the patient had had drainage for empyema, he found a phlegmon in another part of the chest from previous aspiration. The accident could be avoided. Whenever he punctured a chest in a suppurative case, he left the needle in, took out the syringe, filled it with alcohol and injected a little into the chest-wall as the needle was withdrawn. Since he had been doing that he had not seen a single case of chest-wall phlegmon. The accident was more common in children than in adults. Another thing: in diagnosing, the first noticeable phenomenon in the average case of empyema is to note the contraction of the

side affected. It does not, as some have stated, bulge. As Bisgard has written, the ribs become triangular in cross-section very early which was one of the reasons for the contraction of the chest-wall. In cases in which one operated and came upon a foul, anaërobic pus, it was Doctor Lilienthal's practice to moisten a piece of gauze in polyvalent anti-gas-gangrene serum, and pack the chest-wall through the incision with it. This was expensive, but not so much so in the end as a purulent infection of the chest-wall would be.

As to röntgenology, careful use of this would show encapsulation, so one could know where to go directly into it. Doctor Lilienthal said he did not use Potain's aspiration and he noted that neither did Doctor Neuhof. In operating for chronic empyema, he recommended a method modified from that of which Doctor Martin had spoken. It was the simplest way and left no deformity. It was well worth remembering. He used the usual Torek incision, and with two rib spreaders opened the chest wide, did a De Lorme's decapsulation and then had the anæsthetist blow the lung to the surface. A separate drainage opening was made at a lower level for a drainage tube, the long incision being closed by suture. Doctor Lilienthal did the Ransohof operation in those cases in which the lung could not be expanded. Almost no deformity resulted.

Dr. Frank B. Berry stated that for the last ten or twelve years he had been working with Doctor Lambert on the subject of tuberculous secondary empyemata. They present one of the most difficult problems with which the surgeon has to deal. At the present time there were a number of cases, some of which had healed entirely after the simplest operation, and others only after six or seven successive operations. Others were still unhealed. One that came to mind had had the tuberculous process completely arrested, but the empyema cavity remained as a mechanical problem: he was at work supporting his family and did not wish anything further to be done. There were one or two cases now leading a useful life who had calcified pluræ and wore a small tube. The idea they were approaching in this study was first to do an extensive pneumolysis by separating the parietal pleura from the ribs and firmly packing the space as a preliminary operation. It was hoped this would result in more permanent cures where fistulæ were present. Two cases had already been healed by repeated operations and another appeared to be healed. After extensive collapse by thoracoplasty with a resultant small opening, it was felt it might be possible to do a Schede operation and allow the cavity to close by granulation.

EDITORIAL ADDRESS

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